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THE JOINING OF GLASS WITH ORGANICS

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Introduction

The use of organics for joining glass to itself and to other substances may be attributed to the improvement of glass adhesives which is largely responsible to the development of high polymer chemistry. In the laminated glass industry the joining of glass is almost exclusively through the use of a polyvinyl-butyral interlayer which provides the necessary flexible film and also promotes its own adhesion. The more recently developed high molecular weight materials are now available for formulating adhesive combinations which will aid materially in bonding glass to itself and to other surfaces. Synthetic resins available as glass adhesives consist primarily of polymeric substances in different stages of polymerization and secure adhesion either by curing under pressure at elevated temperatures, by solidification through volatilization and evaporation of the solvent carrier, or by condensation and addition reactions.

The affinity or reactivity of the polymer for a surface is associated with its physical and chemical properties which are manifested by the polymeric molecule through its functional groups or side chains. Other forces that may be operative are induction, polarization and dispersion effects of the molecules, as well as the electrostatic attractions. Considerable research has been devoted to obtaining finite values for some of the fundamental properties by attempting correlations with the adhesion secured from various polymers on respective surfaces, but as yet the fundamentals responsible for adhesion of high polymers are still discussed only as generalities.[1, 2]

Glass offers certain advantages as material for studying adhesion in that the visible substrate provides a means for observing bond formation. However, it is not entirely an inert material though its non-crystalline structure, according to Warren[8], is essentially a Si-O-Si-network with a surface exposure of Si-O or Si-O-Na building units. The incomplete $Si-O_4$ group react readily with water vapors or other gases gradually hydrolyzing to form SiOH surface units. This polar structure offers possibilities for either chemical bonding through oxygen linkages or hydrogen bridging depending upon previous reactions of the unsatisfied SiO_4 tetrahedra.

Inasmuch as there is no established relationship between the theoretical evaluations and bond formation, this investigation was initiated to determine bond strength which may be used in future correlations. An analysis of the behavior of the respective polymeric material, as a glass adhesive, was considered an initial approach to this basic problem of adhesion. Adhesive assemblies were prepared and numerical values expressing bond strength in pounds per square inch were obtained for numerous commercial adhesives and for some pure resins.

Types of Adhesives

Organics suitable for joining glass surfaces include the majority of the thermoplastics and some of the thermosetting resins. The polymeric combinations which may be selected as glass bonding materials are dependent upon the particular fabrication. Usually transparent bonds are desired which possess sufficient bond strength to hold the assembly together under varied environmental conditions. Also, the adhesives must not be too brittle or have too much film shrinkage during the curing cycle to cause stress concentrations that will ultimately fracture the glass. Adhesives must have either compatible chemical groups, certain physical attractions and molecular orientation, or provide induced electrical charges for linkages. Often the compatibility of dissimilar surfaces is improved by the application of a primer coat to one of the substrates. The increased adhesion obtained on glass surfaces by such surface orientations have been previously reported[4] and were shown to be very effective for bonding butyl rubber to glass and for increasing tensile strength of the modified phenolic adhesives between glass surfaces.

Organics which may qualify as glass adhesives from the standpoint of compatibility, clarity and bond strength are: the cellulose esters, rubber modified phe-

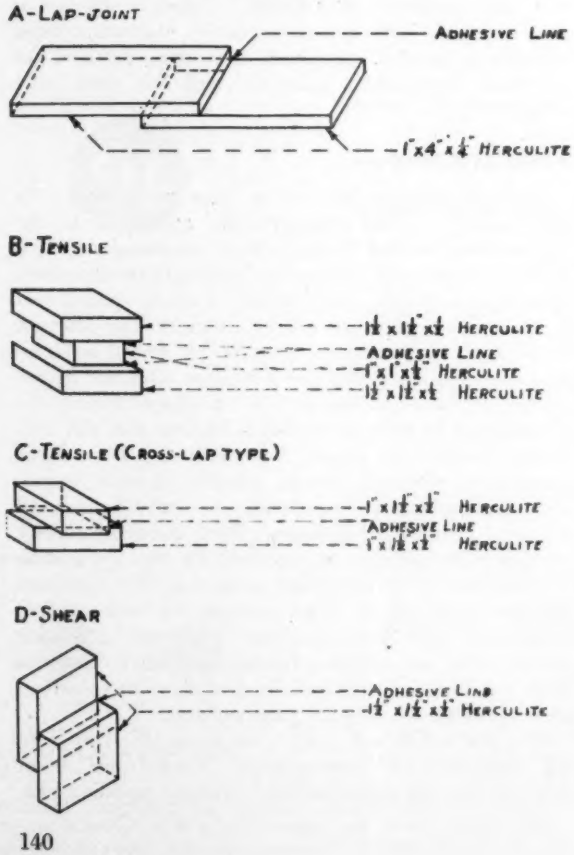
nolics, the vinyl-phenol combinations, the polyvinyl acetates and copolymers, the alkyds, the acrylates and the modified ureas. However, if transparency is not required, the rubber based adhesives have excellent adhesion to glass. These include the natural and reclaimed rubbers and the synthetic elastomers, especially butadiene-acrylonitrile, Neoprene and the thiokol types.

Testing Procedure

The testing of adhesives is almost a problem within itself as many factors complicate the evaluation of the bond. The majority of strength tests were designed for testing to destruction and, therefore, failure may occur either in adhesive film (cohesive), at the interface of the substrate and the adhesive film, or in the adherent itself. Committee D-14 of the American Society of Testing Materials was organized to promote a study of adhesives, and to formulate methods for their testing. In view of the fact that the fundamentals of adhesion are not clearly understood, the committee has taken the more pragmatic approach and has attempted to develop methods of testing which are simple and easy to perform although the test may not be limited to the measurement of a pure stress.

Exploratory studies using various specimens, as lap joint, tensile and shear, were initiated with glass as the testing material. Various test specimens used in this study are shown in Figure 1. The lap joint test employs a transverse fixture using ¼" thick Herculite glass with one square inch of bonded area. However, the test was discarded due to rupture of the tempered glass occurring before bond failure. Also, pure stresses were difficult to obtain as both tensile and shear forces were operative. The shear test gave some improvement over the flexural specimen, but the test is complicated by bending moment, couples and stress concentrations causing glass failure more often than giving a true value for the adhesive material. However, such tests may be considered adequate if the viewpoint is taken that failure occurring in the material rather than in the polymeric film is sufficient proof that the bond is more durable than the fabrication.

FIGURE 1



The tensile specimens illustrated in Figure 1 as "B" and "C" approach more closely the measurement of a single stress. The glass tensile test specimen is a modification of the A.S.T.M. D-897-46T tentative standard[5]. The apparatus, the preparation of test specimens and testing procedure have been previously described[4] and such results have shown that reproducible values were obtained on tempered glass surfaces with failure usually occurring in the adhesive or at the interface. The cross-lap specimen is in keeping with the theme of a simplified test, being encouraged by the A.S.T.M., and offers the advantage of having only one interfacial area.

A comparison of the bond strength of the two tensile specimens are given in Table 1 for a glass to glass assembly.

TABLE 1

BOND STRENGTH AS DETERMINED BY THE REGULAR AND CROSS-LAP TYPE

Adhesive	*Bond Strength in p.s.i.*	
	Cross-lap Specimen	Regular Specimen
Acrylate	770	630
Modified Phenolic	1520	1575
Phenol-Butyral	1540	1650
Phenol-Buna-N1	1320	1500
Phenol-Buna-N2	1440	1200
Vinyl-Buna-N	1000	1220
Modified-Phenolic	1450	1170
Vinyl-Phenol	1540	1240

The data from testing the two types of specimens show very similar values for bond strength coming within the inherent error of the large 10,000 pound dynamometer with its scale of 100 pound divisions. Apparently, either of the two types will give a reliable estimation of the tensile strength of an adhesive for glass surfaces.

Adhesive Evaluations

Adhesive testing involves performance under all types of conditions and preferably in an environment similar to conditions encountered in service. Therefore, accelerated weathering tests which simulate the actual exposure were attempted in order to determine the behavior of adhesive assemblies in the laboratory from which their ultimate strength and permanence could be predicted. Strength obtained at six different exposures are given in Table 2 for the eight commercial adhesives which have shown the most promise from previous screening tests. All values were obtained using heat

tempered glass as the substrate. The exposures, as listed in Table 2, are self-explanatory except the Atlas Weatherometer which is the twin arc-model and has a mechanism for constant rotation of the specimens in an atmosphere supplied with ultraviolet light from two arc lamps. The air temperature is regulated at 120°F and has a three minute water spray over the mounted specimens for each 20 minute cycle.

The mechanism of bond formation between high polymers and glass surfaces will not be discussed in detail, but the data from the comparison of various polymers indicate that the orientation of the polymer molecule, or the presence of functional groups may influence the adhesion secured. For example, in Table 2 bond strength for various exposure conditions show that strength appears associated with the more complex molecule having possibility for orientation. Combinations of phenol either with the vinyl compounds or the rubbers give higher tensile strength than the rubber based, cellulose or acrylate type. An acid catalyzed phenolic resin has little or not adhesion to glass surfaces (10 p.s.i.), whereas a phenolic-butyral combination has approximately 1200 p.s.i. Vinyl resins as vinyl acetate gave 660 p.s.i., while vinyl in combination with phenol or with a Buna N-elastomer gave approximately 1200 p.s.i.

However, initial adhesion expressed in p.s.i. cannot be considered the only criterion for adhesiveness. As in Table 2 the number 5, 7 and 11 adhesives, that maintain an appreciable adhesion under all weathering conditions, may be more desirable than those having high initial strength, but virtually lose the adhesion upon immersion in water or roof exposure as exemplified by the number 11 and 13 adhesives. Factors which are associated with bond deterioration have not been fully established. Bond strength ultimately may be influenced by adsorption of water vapors or other gases which collect at the interface or are absorbed by the adhesive film destroying the adhesion by changing the chemical nature of the molecule which in turn may cause a shift in its orientation, or in its electrostatic attractions. The adhesive in which the film is more hydrophobic appears to have better weathering qualities, than the one which readily absorbs moisture. This is indicated by the above data. As the acrylates, cellulose and the vinyl acetates gave poor resistance to weathering including moisture and ultra-violet light; whereas some of the modified phenolics, the Neoprene based and the thiokol types showed better weathering characteristics. Exposure three, the Atlas Weatherometer, and exposure six, constant high humidity, are perhaps the more severe tests, and if the adhesive maintains an appreciable amount of its original strength after aging under these two conditions, it has considerable permanence and may be suitable for production providing its other physical characteristics are desirable for the fabrication. For interior use the majority of the types are suitable as values in most cases were identical after one year exposure at room temperature, with those obtained initially. However, for joining glass the initial strength, clarity of bond and weathering qualities must all be considered in choosing an adhesive.

Cure

The curing cycle is extremely important in the bonding of transparent materials as a good bond includes an adhesive film free from voids and other imperfections, as well as sufficient strength to support the fabrication. The studies on the curing of the thermoplastics and phenolic adhesives were undertaken as the suitability of commercial adhesives had not been established for glass, being designed either for metals or other varied material. For metal to metal bonds, strength and elasticity of the adhesive film are perhaps the more important requisites; whereas a glass-glass bond must possess the same requisites, but in addition should have a transparent film free from voids or cracks upon aging.

Solvents and monomeric liquids are utilized in the formulation of solution adhesives and are essential to cause solubility of the polymeric material and to wet the surface of the adherent. Manufacturer's recommendations vary widely for the same based adhesive material

TABLE 2—TENSILE STRENGTH OF VARIOUS TYPES OF ORGANIC ADHESIVES UNDER VARIED ENVIRONMENTAL CONDITIONS

Type and No.	Bond strength of glass to glass assemblies after exposure at: Exposure 1 48 hrs. room temperature		Exposure 2 1 yr. at room temperature		Exposure 3 200 hrs. exposure Atlas Weatherometer		Exposure 4 7 day water immersion at room temperature		Exposure 5 1 yr. roof exposure		Exposure 6 10 days in 88% R.H. at 120°F.	
	p.s.i.	failure	p.s.i.	failure	p.s.i.	failure	p.s.i.	failure	p.s.i.	failure	p.s.i.	failure
Alkyd—1	200	adhesive	100	adhesion	200	adhesive	130	adhesive		no test	0	separated during test
Acrylate—2	770	adhesive		no test	0	separated during test	0	separated during test	0	separated during test	0	separated during test
Buna N-Phenol—3	1060	cohesive	800	adhesive & cohesive	960	adhesion	1000	cohesive & adhesive	160	adhesive	790	adhesive
Buna N-Phenol—4	1215	cohesive	1630	cohesive	980	adhesive	880	adhesive	1040	adhesive	260	adhesive
Buna N-Vinyl—5	1220	cohesive	1500	cohesive	440	adhesive	900	adhesive		no test	620	cohesive & adhesive
Cellulose Vinyl—6	790	adhesive	800	adhesive	75	adhesive	250	adhesive		no test	0	separated during test
Modified Phenolic—7	1575	glass surface	1400	adhesive	1400	glass surface	1060	adhesive	1400	glass surface	600	adhesion
Modified Phenolic—8	1170	adhesive	925	adhesive	430	adhesive	980	adhesive	280	adhesive	670	adhesion
Phenol-Vinyl Acetal—9	1650	adhesive	1215	adhesive	980	adhesive	880	adhesive	175	adhesive	300	adhesion
Polyvinyl Butyral—10	1230	adhesive	1000	adhesive	1090	adhesive	530	adhesive		no test	0	separated during test
Thiokol—11	200	cohesive	350	cohesive	0	separated during test	115	adhesive	240	adhesive	250	adhesion
Vinyl-Phenol—12	1240	adhesive	1500	adhesive	975	adhesive	1170	adhesive		no test	1000	adhesive failure
Vinyl Acetate—13	660	adhesive	480	adhesive	0	separated during test	0	separated during test	205	adhesive	140	adhesive
Rubber Based—14	200	adhesive	300	adhesive	0	separated during test	160	adhesion	65	adhesive	130	adhesion

TABLE 3—EFFECT OF CURING CYCLE UPON STRENGTH AND CLARITY OF BOND OBTAINED FROM TRANSPARENT THERMOPLASTICS FOR JOINING GLASS

Adhesive Type	No.	Bond Characteristics and Strength With CURE A p.s.i.	CURE A Character of bond and failure	CURE B p.s.i.	CURE B Character of bond and failure	CURE C p.s.i.	CURE C Character of bond and failure	CURE D p.s.i.	CURE D Character of bond and failure
Acrylate	1	275	Voids prevalent Adhesive failure	510	Clear Adhesive failure	310	Voids present Adhesive & contact failure	360	Clear, flexible Adhesive failure
Cellulose Vinyl	2	790	Voids appear on aging Adhesive failure	800	Clear, some voids appear Adhesive failure	500	Clear, voids appear Adhesive failure	1500	Glass surface
Vinyl Cellulose	3	330	Voids prevalent Adhesive failure	640	Clear Cohesive & adhesive failure	890	Clear Cohesive & adhesive failure	460	Clear, brittle Cohesive and adhesive failure
Vinyl Cellulose	4	425	Voids Adhesive failure	700	Clear, brittle Cohesive failure	220	Voids, brittle Contact failure	760	Clear Adhesive failure
Vinyl Acetate	5	660	Voids appear on aging Adhesive failure	530	Voids Adhesive failure	735	Clear Adhesive failure	2080	Clear Cohesive failure
Vinyl Acetal	6	1230	Clear Adhesive failure	970	Clear, some voids appear Adhesive failure	400	Adhesive & contact failure	460	Adhesive and contact failure
Vinyl	7	420	Clear Adhesive failure	640	Clear Adhesive failure	1460	Clear, elastic film Adhesive failure	1200	Clear Adhesive and cohesive failure

Cure A—Recommended manufacturers' cure for the respective adhesive.

Cure B—Air-dry for one hour, assemble under pressure and heat at 250°F for 30 minutes.

Cure C—Air-dry for 30 minutes, unassembled heat activation at 250°F for 15 minutes, assemble under pressure, and cooled to room temperature.

Cure D—Air-dry for 15 minutes, unassembled heat activation at 250°F for 30 minutes, assemble under pressure and cooled to room temperature.

and consequently for comparison, the adhesive type should be evaluated by identical curing cycles to establish either the superiority or inferiority of one adhesive over the other for glass assembly. Imperfect bonds may be attributed to either entrapped air or an incomplete volatilization of solvent which may cause the adhesive film to bubble on the application of heat and pressure. If solvent is still present, voids may form when pressure is removed after the completion of the cure. Curing cycles are further complicated due to the fact that the transparent adhesives may be derived either from pure resins plus the appropriate plasticizer or from copolymerizing mixtures. Thus, the curing cycle should be of such length and at the temperature range where the last traces of solvent are removed, but not of such length at the respective heating temperature to induce set. The film must be capable of plastic flow to provide intimate contact of the adhesive films to the solid surfaces being joined.

Tables 3 and 4 give bond strength secured from varied curing cycles as well as bond characteristics and type of failures. Cures tabulated under "A" are in accordance with the instructions of the manufacturer of the adhesive and are not identical as some are air-drying cures, while others involve heating cycles. Consequently, Cures "B," "C" and "D" place the adhesives upon a more comparable basis for joining glass surfaces. The formulation of the adhesive base undoubtedly influences the effectiveness of heat for bond formation. Combinations of partially polymerized vinyl and acrylate resins may become brittle and set before contact is made, often resulting in contact failure and lower tensile strength which is shown in the number one and number two adhesives. Others which are a fully polymerized thermoplastic dissolved in a solvent give stronger bonds with a longer heat activation period which is well illustrated in the vinyl types. Thus, in formulating transparent thermoplastic adhesives for glass fabrication, materials that are fully polymerized, and in which all traces of solvent may be removed by heating, are more certain to give a film free from voids than the partially polymerized mixtures which depend upon heat or oxide catalysts to complete the polymeriza-

(*Continued on page* 176)

TABLE 4—EFFECTS OF CURING CYCLE UPON STRENGTH AND CLARITY OF BOND OBTAINED FROM MODIFIED PHENOLIC ADHESIVES FOR JOINING GLASS

Adhesive No.	Cure I p.s.i.	Cure I Character of bond and failure	Cure II p.s.i.	Cure II Character of bond and failure	Cure III p.s.i.	Cure III Character of bond and failure	Cure IV p.s.i.	Cure IV Character of bond and failure	Cure V p.s.i.	Cure V Character of bond and failure
1	490	Voids prevalent Adhesion failure	1070	Clear Adhesive, some glass failure	1250	Adhesive & cohesive failure	1150	Clear	1450	Clear Glass surface failure
2	755	Scattered voids	840	Clear Adhesive failure	1450	Clear Adhesive & glass failure	960	Clear Glass surface failure	710	Clear Glass surface failure
3	600	Scattered voids Adhesive failure	1700	Clear Glass surface failure	1830	Clear Glass failure	1150	Clear Glass surface failure	1710	Clear Glass surface failure
4	350	Cloudy, voids Contact failure	975	Clear Adhesive & cohesive failure	1030	Clear Adhesive failure	1435	Clear Adhesive & cohesive failure	1200	Clear Glass surface failure

Cure I —60 minute air-dry, assembled under pressure, and oven-bonded for one hour at 250°F.

Cure II —60 minute air-dry, 15 minute open assembly, assembled and cured under pressure for 45 minutes at 250°F.

Cure III—60 minute air-dry, 15 minute preheated closed assembly at 250°F, pressure applied and cure completed for 45 minutes at 250°F.

Cure IV—60 minute air-dry, assembled under pressure and cured at 300°F for 60 minutes.

Cure V —60 minute air-dry, preheated closed assembly at 350°F for 10 minutes, pressure applied and cure completed at 350°F for 12 minutes.

THE EFFECT OF CONVECTION CURRENTS ON THE DISTRIBUTION OF STRIAE IN POTS OF OPTICAL GLASS

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PART II

IV. Study of convection currents. (Cont.)

2. *Tracing convection currents.* In order to trace the motion of the glass in a cooling pot, a coloring agent was introduced into the melt just after removal from the furnace. Copper oxide, wrapped with copper screen to form balls about ¾ inch in diameter, was used to provide the color. Two of these balls, each weighted with a steel ball in the center, were permitted to sink to the bottom of the pot, and two were suspended from a bar across the top of the pot, so that they would hang about 4 inches below the surface of the glass. The balls were positioned in the melt so that there would be one ball in each quadrant, approximately half way between the center and edge of the pot.

The copper oxide was readily dissolved by the glass, giving a dark blue or black color. The colored streamers formed by the glass flowing past the copper oxide balls provided the means for determining the direction and magnitude of the convection currents.

Copper oxide balls were placed in thirteen melts, each of which had a somewhat different cooling treatment either during the last hours of melting or just after removal from the furnace and before placing under the cooling can. Beginning with the second melt, the cooling can was provided with windows so that the migration of the colored streamers could be observed. The final positions of these streamers were traced after the pot of glass was cold and opened for inspection.

The various cooling treatments and the results are discussed in the following paragraphs in the order in which they were made.

Melt No. 1. Exit temperature 1025°C.* The only observation made on this melt was just before lowering the cooling can to the floor. The colored streamers from ball D (see Figure 12) were found to have gone down the sides of the pot, across the bottom and up the center. Those from A and B had traveled up the center, across the top, down the sides and then curved upward again. One streamer had formed a definite loop such as shown in Figure 12. This loop was formed by the flow of glass crossing and displacing the colored streak left by the copper oxide ball sinking to the bottom of the pot. (Observations on subsequent melts reveal the formation of this characteristic loop.)

Melt No. 2. Exit temperature 1075°C. The copper oxide balls were introduced immediately on removal of the melt from the furnace. Observation through the cooling can windows indicated that by the time the pot was placed on the cooling piers the balls that were to sink had already reached the bottom, leaving dark streaks behind them. The color from the suspended balls had gone a considerable distance, but had gone toward the center of the pot, then down. About 10 minutes later the directions appeared to have reversed; the original colored streaks had come back up the center, leaving a blotch of color on top which was moving toward the sides. Then the streaks were observed to go down the sides and up the center, across the top and down the sides again. A slight clockwise motion around the pot was evident, causing the colored streaks to form spirals rather than plane loops. The amount of travel and twisting of the colored streamers soon made it impossible to follow them, but they appeared to make three or more loops. The appearance of the streamers, just before lowering the cooling can, is shown in Figure 13. When the glass was opened for inspection, only the more prominent streaks (Figure 14) could be followed, but not too well. The photograph, Figure 15, of both halves of the melt when cold, shows clearly the excessive movement that occurred.

Melt No. 3. Exit temperature 1025°; water-cooled rod in center of pot. A water-cooled rod was placed in the center of this melt after removal from the furnace. Observation of the colored streaks indicated that the movement of the convection currents was slightly less than in other melts removed from the furnace at 1025°C, and the direction of travel was reversed. The streaks, as located in the cold glass, are shown in Figure 16. Due to somewhat unsymmetrical cooling, the streamer from A appears to bend back on itself. However, it is practically the same as that from B, but is directed along the pot wall rather than toward the center. Color from the suspended balls C and D moved very little.

Melt No. 4. Exit temperature 1025°; water cooled. Immediately after removal from the furnace the copper oxide balls were placed in the pot, the melt then placed on a cooling rack and sprayed with water** on the bottom and on the sides up to the pot knuckle, or shoulder. The

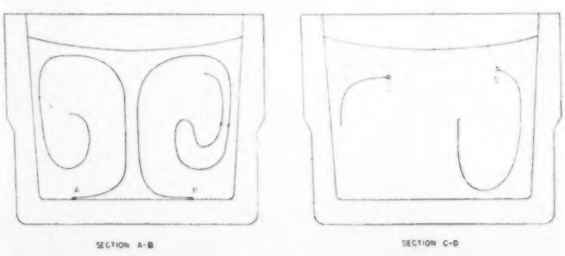


Fig. 12. Final position of the copper-oxide tracers in melt No. 1.

* Exit temperature is the temperature at which the melt was removed from the furnace. Unless otherwise stated, the temperatures given here are those indicated by an optical pyrometer sighted on the surface of the melt through the stirring rod opening in the door of the melting furnace.

** An ordinary shower head, inverted, provided the spray for the bottom of the pot. A tabular ring perforated with a large number of small holes, suitably directed, provided the spray for the sides of the pot.

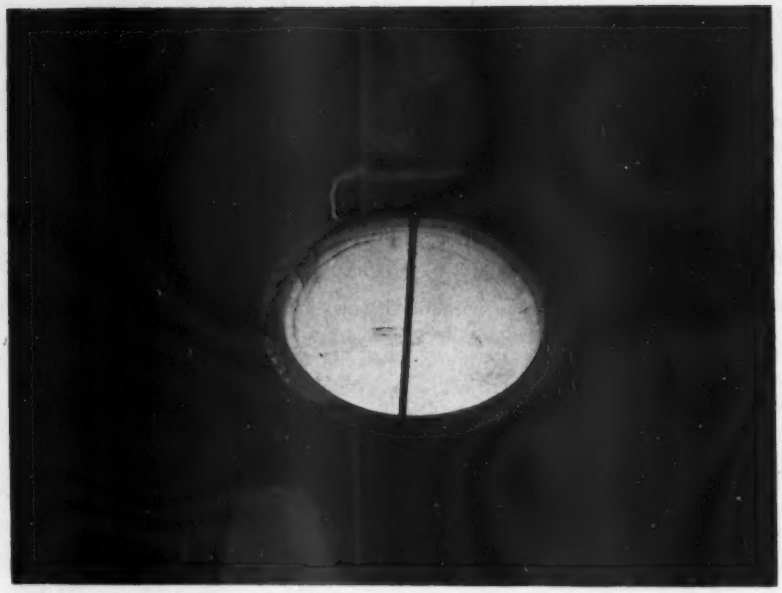


Fig. 13. Photograph of the copper-oxide tracers in melt No. 2. The portions of the tracers deep in the glass show up as light streaks; those near the surface are dark.

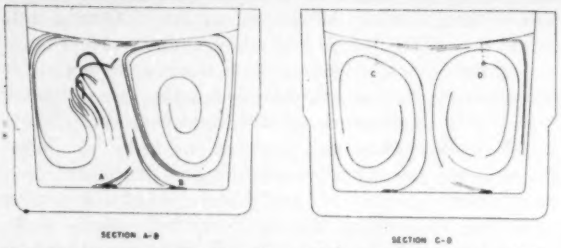


Fig. 14. Approximate location of the main portions of the copper-oxide tracers in melt No. 2 when cold.

water spray was applied for thirty minutes and the pot then transferred to the regular cooling piers. The balls A and B were somewhat slow in sinking to the bottom due to the chilled surface of the glass which was not covered during the spraying period. On sinking, these balls left streaks of color behind which, after a few minutes, curved inward at a position about two-thirds of the way down. After about 45 minutes these curved portions had formed loops which had progressed toward the center of the pot and upward. The formation of these loops gives the effect of double streamers. They are caused by the flow of glass from near the pot wall crossing the color paths left by the balls in the sinking. The formation of these loops is illustrated by the sketches in Figure 17. Figure 18 shows the final position of the colored streamers in melt 4.

Melt No. 5. Exit temperature 1025°; water cooled, with lid. This melt was covered immediately on removal from the furnace with a lid made of insulating brick 4½ inches thick to prevent rapid chilling of the top surface of the glass while the melt was being water cooled. Due to the lid, observations were necessarily delayed until after the water cooling was finished. At the time of the first observation, the loops in the color streamers had reached the top of the pot and gave the appearance of being double streamers originating from the submerged balls. These streamers did not rise directly in the center of the pot, but slightly to one side, and those portions near the surface were also displaced indicating unsymmetrical cooling.

Fig. 15. Photograph of melt No. 2 when opened for inspection. The numerous streaks from the copper-oxide tracers and their tangled condition illustrate the excessive motion that occurred.

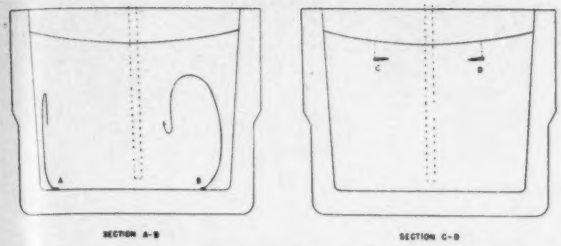


Fig. 16. Final positions of the copper-oxide tracers in melt No. 3 with the water-cooled rod in the center. The streak from A is similar to that from B, but is directed along the pot wall instead of toward the center of the pot.

The paths of the observed currents are shown in Figure 19. The dotted portions shown in the top views represent those portions of the streamers across the bottom of the pot. The final positions of the colored streamers are shown in Figure 20.

Melt No. 6. Exit temperature 1025°; air cooled, with lid. The lid was placed on this melt for the first half hour of cooling in the belief that it would be more effective than the suspended can in keeping the top surface from chilling.

After removal of the lid it was noted that the color from the suspended balls (C and D) had traveled across the top, down the sides, across the bottom and up the center in much the same manner as in melt No. 1. The balls A and B sank in a straight line to the bottom of the pot, leaving colored streaks behind. A and B were placed too close to the edge so that the flow of glass did not displace the streamers as much as in previous melts. As judged subsequently by observations through the top of the insulated can, the positions of these bands at different times were approximately as shown in Figure 21. The positions in the cold pot are shown in Figure 22.

Melt No. 7. Exit temperature 975°C; regular cooling as in melt No. 1. This melt was cooled in the furnace,

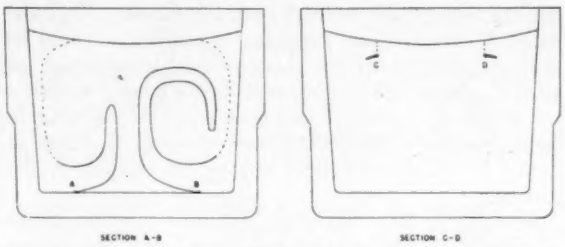


Fig. 18. Final position of the copper-oxide tracers in melt No. 4.

with stirring, to 975°C. The copper oxide balls were placed in the melt. But those that were supposed to sink stayed on the surface and the suspended balls remained stationary. No color streaks developed from any of them. At this temperature the glass was sufficiently viscous that the motion, if any, could not be observed by the use of the copper-oxide balls. The melt was full of striae which appeared to have been dragged from the pot walls by the action of the stirrer.

Melt No. 8. Exit temperature 1050°; remained in fur-

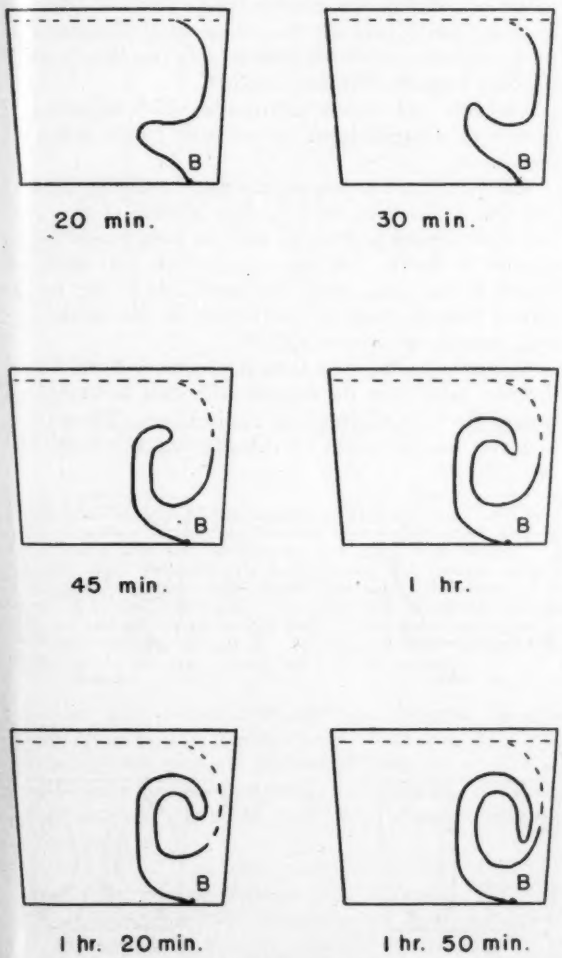


Fig. 17. Sketches of tracer from ball B drawn from observations of melt No. 4 during cooling, showing the formation of loops in the tracers.

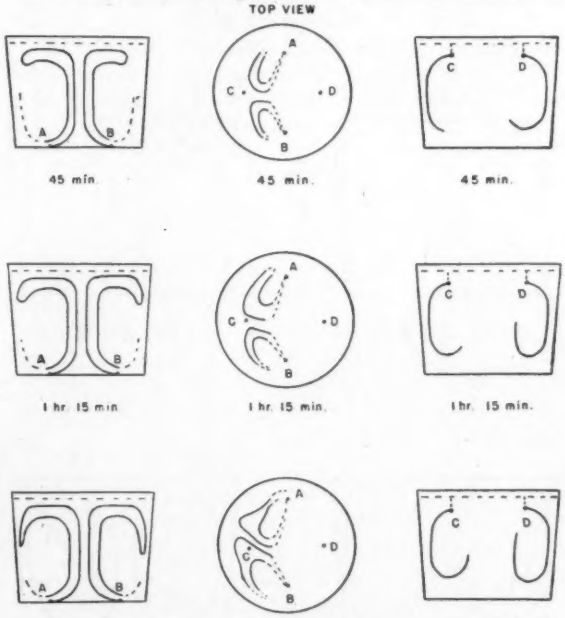


Fig. 19. Sketches drawn from observations of the copper-oxide tracers in melt No. 5 during cooling. The dotted portions shown in the top views represent those portions of the streamers across the bottom of the pot, and the ends of the loops going downward.

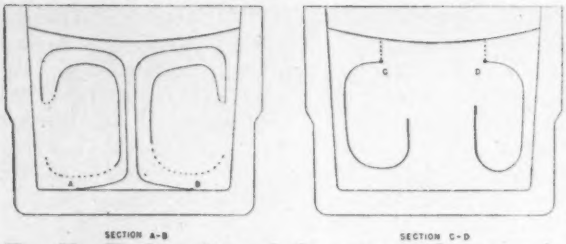


Fig. 20. Final position of the copper-oxide tracers in melt No. 5.

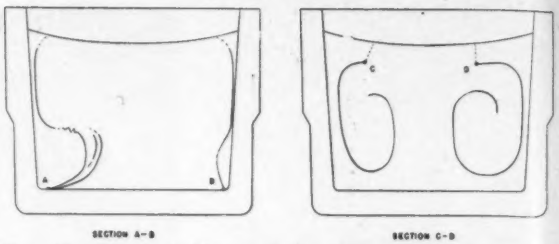


Fig. 22. Final positions of the copper-oxide tracers in melt No. 6.

nace two hours at 1050°. The holding period at 1050°C was intended to establish uniform temperatures throughout the melt before removal from the furnace. This was based on the previous temperature probe and would be about equivalent to the normal exit temperature of 1025°C without the holding period. The motion as shown by A and B Figure 23 was practically the same as in melts removed at 1025°C. However, colors developed at C and D moved very little due to the chilling of the surface.

Melt No. 9. Held two hours at 1050°C; surface raised to 1075° within 15 minutes before removal. The raising of the surface temperature at the end of the holding period at 1050°C was effective in reducing the chilling of the top surface immediately after removal from the furnace. The observed movement of the glass was essentially the same as in the previous melt, except that the color from C and D moved farther. The rapid raising of the temperature to 1075° had very little effect on the magnitude of the convection currents. The cooling was very unsymmetrical, due mostly to an improperly hung can, so that the streamers went down one side of the pot and up the opposite side, rather than raising at the center. The appearance of the streamers as viewed from the top is shown in Figure 24. Also in Figure 24 are shown the final positions of the colors in the cold pot.

Melt No. 10. Held 1½ hours at 1000°C; surface raised to 1025° in 15 minutes before removal. As may be seen from Figure 25, the movement of the glass due to convection currents was considerably less than in melts removed from the furnace at 1025°C.

The melt had considerable striae which appeared to have been dragged from the pot wall by the action of the stirrer.

Melt No. 11. Exit temperature 950°C; stirring stopped and rod removed at 1025°C. The stirring of this melt was discontinued at 1025°C, and the melt cooled in the furnace to 950°C. The one copper-oxide ball used was placed in the glass along the right side of the pot as viewed from the front of the furnace, as soon as the stirring rod was removed at 1025°C.

On removing the melt from the furnace, it was found that the color from the copper oxide ball had migrated toward the front of the pot in a spiral form. The amount of travel was not great considering that 1½ hours had

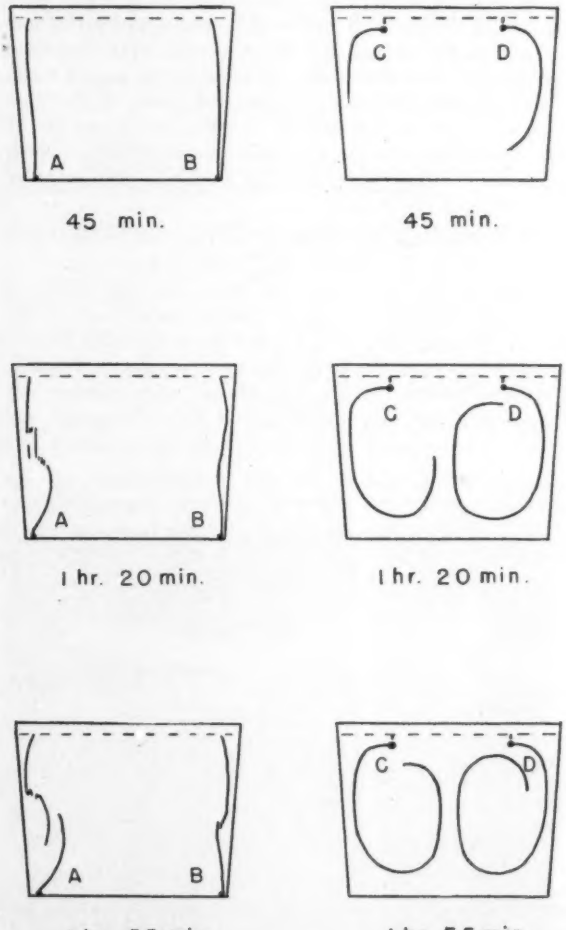


Fig. 21. Sketches drawn from observation of the copper-oxide tracers in melt No. 6 during cooling.

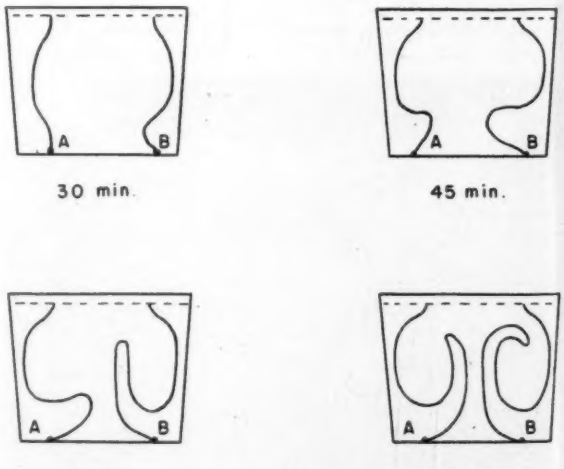
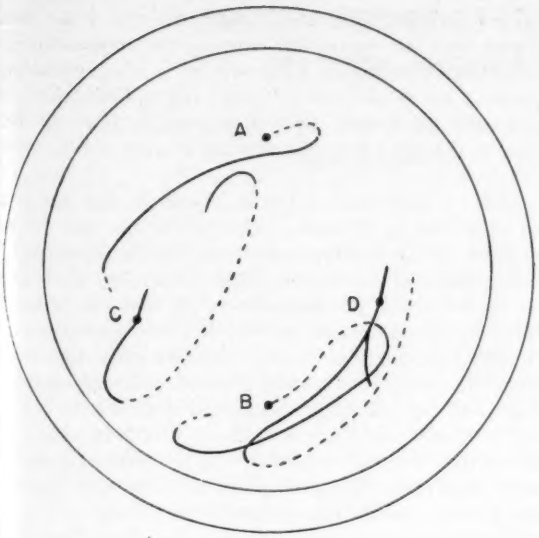
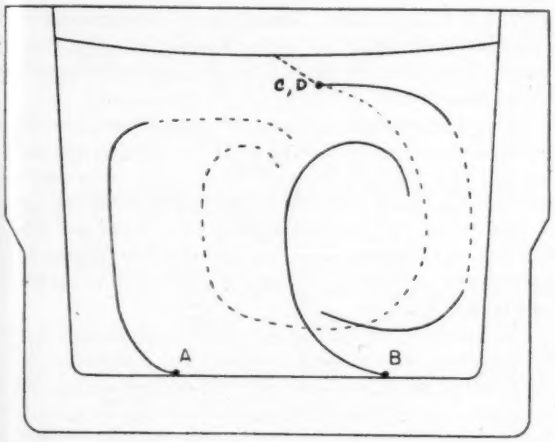


Fig. 23. Sketches drawn from observations of melt No. 8 during cooling.



TOP VIEW



SECTION A-B

Fig. 24. Position of the copper-oxide tracers in melt No. 9. The top view represents the last observation made through the cover after all motion of the glass had ceased. The dotted lines indicate the portions of the tracers deep in the melt. Section A-B shows the final positions of the tracers in the cold melt. The solid lines show the portions of the tracers visible in the half of the pot containing ball D, and looking toward D. The dotted lines indicate portions of the tracers in the other half of the pot.

elapsed since the end of the stirring. However, the spiral path taken by the streamer shows that some convection currents were present. As viewed from the top the colored tracer appeared as shown in Figure 26. No motion was observed after the melt was removed from the furnace.

Melt No. 12. Exit temperature 950°C; stirring stopped at 1050°C; cooling ports in back of furnace. This melt was similar to melt No. 11, except for additional cooling of the bottom of the pot provided by openings in the back of the furnace.* Stirring was stopped at 1050°C

* These openings were 8 by 8 inches, spaced 3 feet apart and about level with the bottom of the pot.

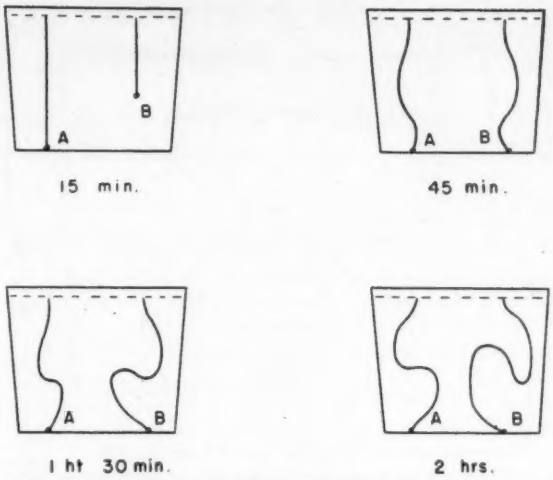


Fig. 25. Sketches drawn from observation of melt No. 10 during cooling.

and a copper oxide ball was placed in the melt, at the front edge of the pot, when the temperature reached 1025°C. One and one-half hours later, when the melt was removed from the furnace, the colored tracer appeared to have made three-fourths of the loop. The color progressed from the copper-oxide ball across the bottom of the pot, rising near the far side, then across the top toward the front of the pot. A separate streak, caused by oxide left behind as the ball sank, was also visible. This streak was not connected to the main tracer, but gave the appearance of completing the loop. Only a very slight movement was observed after the melt was removed from the furnace. This was shown by a slight migration of the top portion of the streak toward the side of the pot. The positions of the colored streaks in the cold pot were as shown in Figure 27.

Melt No. 13. Exit temperature 1050°C; cooling ports in back wall of furnace opened. Melt No. 13 was cooled with the back wall ports open, and removed at 1050°C.

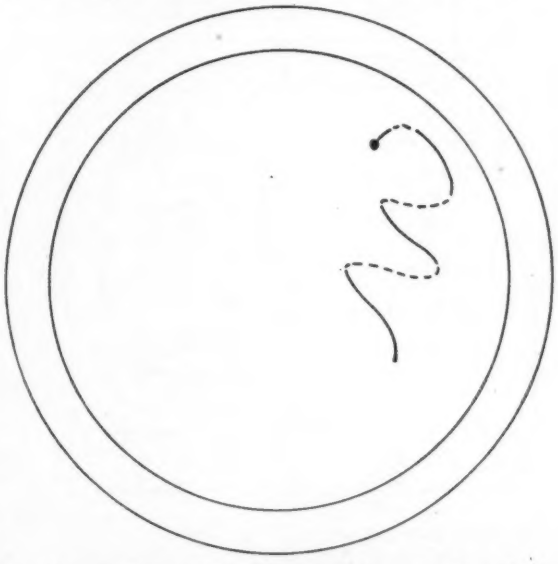


Fig. 26. Top view of the copper-oxide tracer in melt No. 11. The dotted lines indicate the lower portions of the spiral and the solid lines indicate the upper portions.

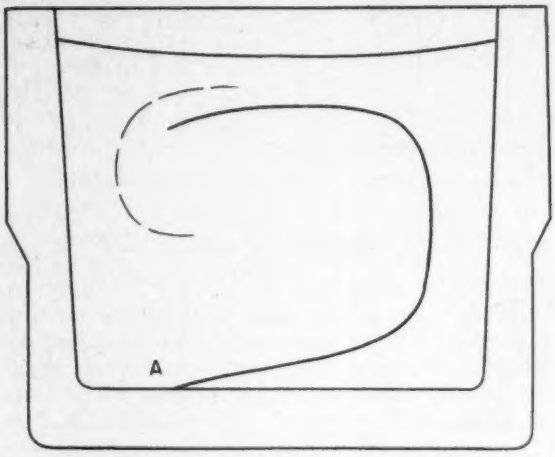


Fig. 27. Final position of the copper-oxide tracer in melt No. 12. The dotted lines indicate portions of the tracers in the other half of the pot.

The movement of the glass was such that in 40 minutes the color streaks had made a complete turn, and a half hour later had made the second revolution. They were soon too difficult to follow. Inspection of the cold pot showed the main streamer from ball D to have made 2½ turns, and was accompanied by a few secondary streamers caused by disintegration of the copper oxide ball. The streamers from the other balls were too confused to trace properly. The position of the main streamer from ball D only is shown in Figure 28.

V. Discussion.

The introduction of color into melts of optical glass has provided a means of tracing convection currents in the glass during the cooling process. The positions taken by the colored tracers have been found to be similar to, and frequently identical to the positions occupied by the main striae bands. This correspondence between the observed paths of the colored tracers and the striae bands shows that the convection currents are responsible for the striae distribution. The source of these striae appears to be the glass next to the walls and bottom of the pot, with the greater amount originating from the bottom of the pot where the stirring is least effective (see Figure 4).

The top horizontal band, in Figure 5, that seems to be unrelated to the main striae bands, can also be accounted for by convection currents. There is frequently a movement of the surface glass (melt No. 2) toward the center of the pot immediately on removal from the furnace; this movement reverses direction when the melt is placed beneath the cooling can. The early motion toward the center could carry glass of different composition from the pot walls and spread it across the top of the melt near the surface where it would be frozen in before the direction of motion was reversed. The heavy band, in Figure 6, shows a distinct loop which could also be explained by this reversal of direction.

The various procedures tried for control of convection currents were only modifications of the standard cooling procedure. Of the various modifications tried, the lowering of the exit temperature was by far the most effective. However, this procedure could be carried out only to a limited extent. When the exit temperature was reduced below 1025°C (melts Nos. 7 and 10), striae were dragged into the glass from the pot walls by action of the stirrer.*

In regular production, melts of borosilicate glass were removed from the furnace at 1050°C whenever the cooling ports in the back wall of the furnace were used to increase the cooling of the bottom portion of the pots. It was found, however, that these ports were not effective for the purpose intended and that the higher exit temperature tended to increase the convection currents (see melt No. 13).

The procedure of cooling the glass in the furnace after discontinuing the stirring reduced the convection currents, but some striae were still evident and appeared to be deeper in the glass. This procedure may be more effective if the stirring could be carried to a temperature well below 1025°C.

The use of the water-cooled rod in the center of the melt provided too much local cooling and reversed the direction of the convection currents. Although the amount of motion was reduced, the heavy bands of striae were directed downward approximately half way between the center and the walls of the pot, resulting in a more than the usual loss of glass.

Water cooling the outside of the pot for ½ hour had practically no effect on the magnitude of the convection currents. The use of the insulating lid only served to direct the striae closer to the pot walls and the surface of the glass.

It was found that the paths of the colored streamers, and consequently the striae layers depend to a great extent on the symmetry of cooling. To avoid excessive loss of glass from striae, considerable care must be taken to assure that the cooling can is properly placed and the melt allowed to cool symmetrically.

The loss of glass due to the introduction of color was not significant, unless the motion of the glass during

(*Continued on page* 168)

* Further reduction of the exit temperature may be possible by the use of a slower speed than that now available, namely, 6 rpm.

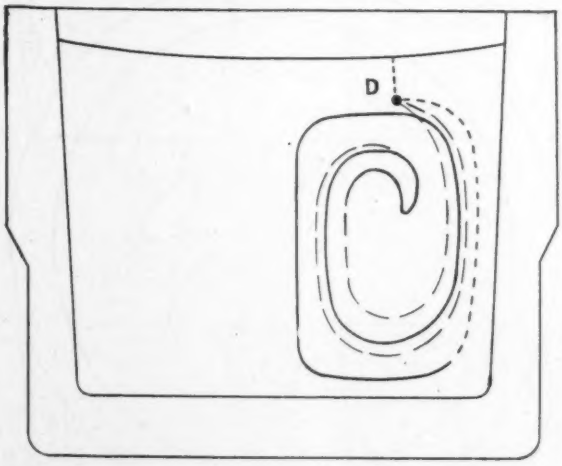


Fig. 28. Final position of the copper-oxide tracer from ball D in melt No. 13. The dotted lines indicate portions of the tracers in the other half of the pot.

INSTRUMENTATION AND CONTROL OF GLASS MELTING OPERATIONS

By JOHN R. GREEN, Manager Steel & Ceramics Division
Brown Instrument Company, Philadelphia, Pa.

The application of instruments and automatic controls to glass melting units can be approached from two directions. Each type of commercially available instrument equipment can be described as it is applied to different aspects in this process. Or the over-all objectives of melting operations may be considered in light of the involved engineering principles, showing how each phase can be assisted by all types of instrumentation. The latter approach will be used in this discussion even though some repetition of instrument characteristics is inherent in such a treatment.

In order to cover the most complex form of operation, a multipoint continuous tank is used as an example to illustrate the greatest variety of operating requirements. Day tanks, pot furnaces and tanks employing end-firing or recuperation are all adaptable to variations or parts of the same principles.

A schematic layout of such a continuous regenerative furnace, showing many of the standard instrument applications, is illustrated in Figure 1. Reference will be made to this diagram in covering individual phases of tank instrumentation.

Paper presented before the Tenth Conference on Glass Problems, Ohio State University, Columbus, Ohio.

Objectives at Glass Tank Operation

In brief, the fundamental objectives of glass tank operation are in melting and refining the raw materials which are changed to the tank. It includes delivering a product to the various types of forming operations required by the product being manufactured. The glass quality, as a result of melting and refining, is of prime importance. The product must have minimum seeds, stones and cords, as well as the proper color and viscosity, for handling in the forming operations.

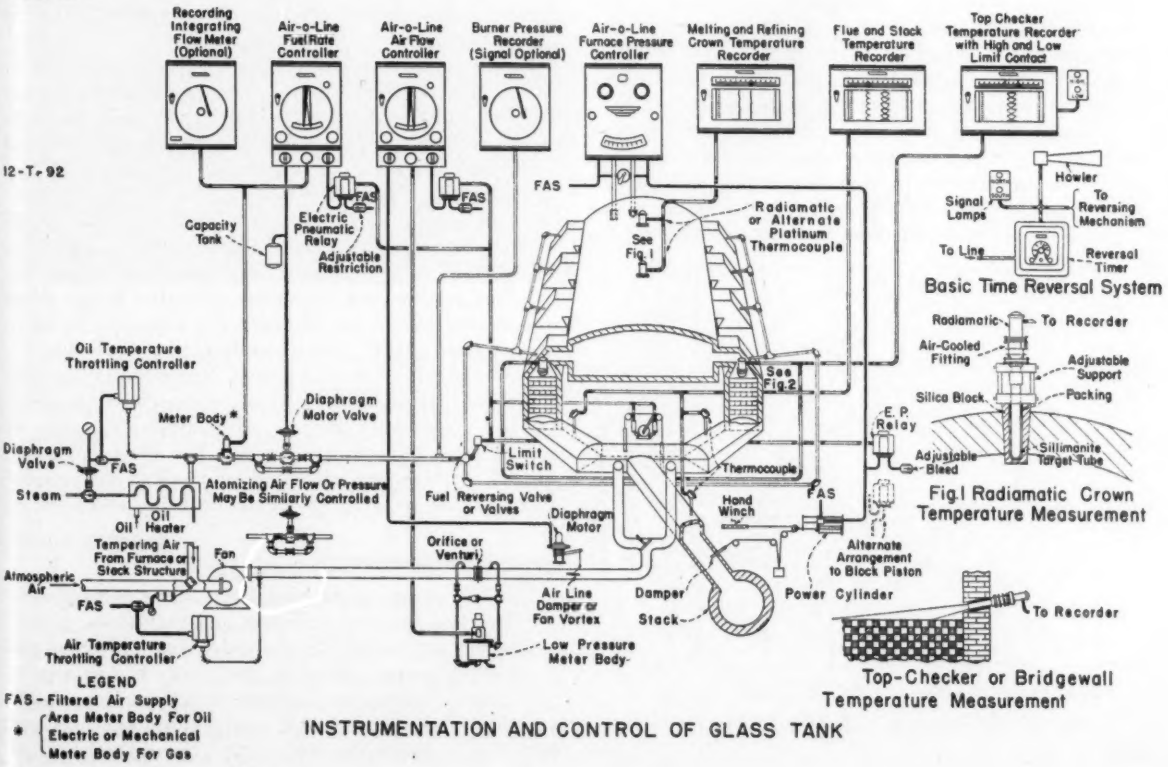
The next objective is to obtain lowest operating cost per ton of product, including fuel, refractories, and operational labor cost and maintenance. The third objective is continuity of operation or length of tank life.

Factors Affecting Glass Quality Capable of Instrumentation

A number of factors affecting glass quality are capable of modern instrumentation. These include: 1) temperature of the glass in the tank, 2) a distribution of that temperature both progressively from the melting through the refining operations and also transversely across the tank.

A third factor is the influence of furnace atmospheres

FIG. 1.



INSTRUMENTATION AND CONTROL OF GLASS TANK

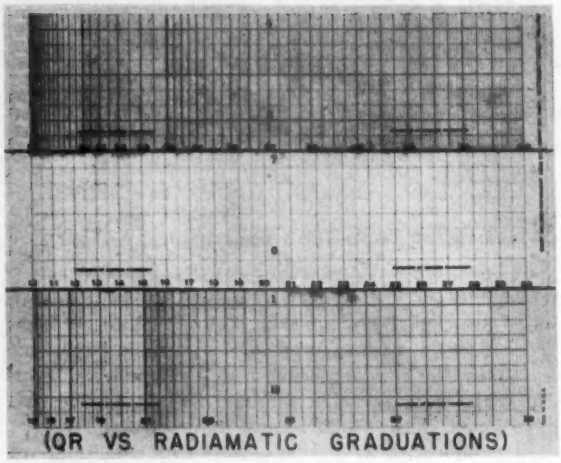


FIG. 2

as they affect the chemical reactions of melting and refining. A fourth factor is the maintenance of glass level, which has its influence upon the consistency of the forming operations.

Measurement of Glass Temperatures And Temperature Distribution

The instruments and controls which are used directly or indirectly in maintaining these quality factors include a variety of measurements.

Continuous measurements of glass temperatures may be made by means of thermocouples permanently installed either through tank bottoms or side walls. Periodic readings made by means of thermocouples lowered through the crown or by means of water cooled elements inserted through ports in the side walls are in rather extensive use in the glass industry. Radiation measurements of glass temperatures in the refiner have proven themselves to be advantageous in the container industry.

A distribution of temperature throughout the furnace structure is almost universally measured by the recording of crown temperatures in both the melting and refining chambers. A comparatively recent inprovement in this form of measurement has been made possible by the use of modern radiation elements, as illustrated in Figure 1.

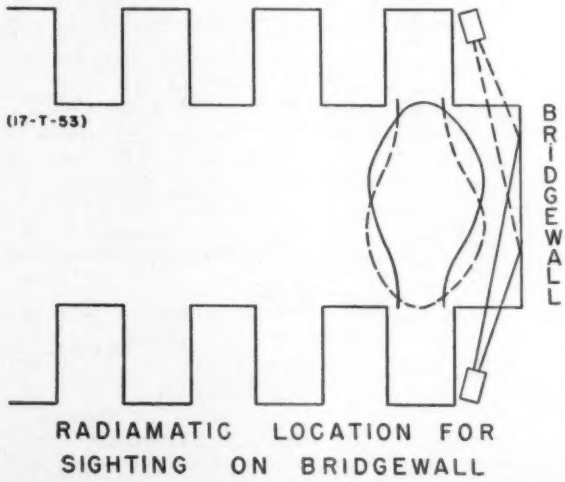


FIG. 3.

The operating advantages of this method by comparison to platinum thermocouples are 1) the elimination of platinum deterioration, since the entire measuring element is located outside of the high temperature zone; 2) lower replacement and maintenance costs, including an easy replacement of secondary target tubes; and 3) an expanded temperature scale at the operating temperatures. Figure 2 illustrates comparison of chart divisions between platinum thermocouples and radiation measurements over normal operating temperatures.

The ability to continuously measure bridge-wall or shadow-wall temperatures by means of radiation, in addition or supplementary to periodic measurements of this temperature by means of optical instruments, has been of material assistance in tank operations. Figure 3 is a schematic diagram illustrating how such measurements are taken in order to avoid interference from flames.

In end fired tanks, flame impingement on the bridge wall during high firing rates may make this form of measurement impractical. Figure 4 illustrates a method of mounting radiamatic elements for this measurement and Figure 5 shows a typical chart of bridge-wall temperatures, which are closely related to glass conditions at that important point.

The measurement of flame radiating power is a useful research and design tool, particularly with oil firing, and aids in controlling the distribution of radiant energy transfer throughout the flame length.

Control of Temperature Distribution

Distribution of temperature throughout the furnace is controllable through a number of factors which are capable of instrumentation, as shown in Figure 1. Automatic furnace pressure regulation has a direct influence on flame distribution throughout the furnace as well as flame propagation.

Uniform fuel flow rates to both sides of the furnace, and throughout the period of firing in one direction, has a direct effect on temperature variations from one side of the tank to the other. The temperature of preheated air which influences the rate of flame propagation, and the temperature distribution across the furnace, continuously changes with the continuation of firing in one direction. The frequency of furnace reversal, therefore, also influences the temperature distribution. These instrument applications, discussed at further length when considering combustion efficiency, are important in maintaining glass quality, which should not be overlooked.

The control of glass or tank temperatures through automatic regulation of fuel rates is considered impractical for regenerative furnace. The available points of measurement, if sensitive enough for good automatic control purposes, are influenced too much by the reversal operation for securing an automatic firing schedule.

Furnace Atmospheres

The importance of maintaining furnace atmospheres, i. e., relation between oxidation and reductions, is well recognized, particularly in the maintenance of color and in securing proper fining of the glass. Unfortunately, very little practical gas analysis equipment is available to analyze these conditions at temperatures and locations immediately above the glass bath. The control of fuel

and air flow rates or ratios, and the maintenance of furnace pressures to stabilize infiltration and rate of combustion are the most practical means for maintaining desired atmospheres from a quality as well as combustion efficiency standpoint.

Glass Level

The continuous measurement or automatic control of glass level, either from the furnace proper or associated forming units, can properly be considered a melting factor for influencing the quality of the product.

This consists of a motorized electrode, periodically contacting the glass surface, a continuous record of the

FIG. 4.

level so detected, and a means of automatic regulation of batch charger rates. When forming equipment, such as forehearths, are sealed from the tank proper by means of skinner blocks, the effects of tank pressure fluctuations during reversal should not be overlooked as an influence in maintaining constant glass levels.

Fuel Efficiency

In securing the objective of lowest cost per ton of product, the fuel consumption per ton is the most important item. The factors which affect such fuel costs can be classified as: 1) the efficiency of combustion or heat release; 2) heat transfer efficiency, both during firing and throughout the reversal operation; 3) heat recovery in preheated air from the checker systems; and, 4) heat losses in stack gases. The instruments and controls

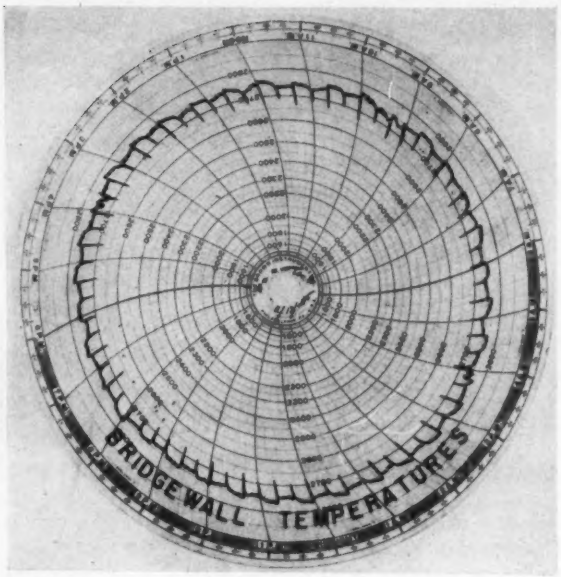


FIG. 5.

used in lowering fuel costs, illustrated in Figure 1, can also be itemized as they apply to these factors.

For efficiency of heat release the measurement and automatic control of fuel and air flow rates is of prime importance. There are many advantages in controlling either gas or liquid fuel flows from flow measurements rather than supply pressures. Figure 6 illustrates a typical flow record when only pressure regulation is used. This chart is on natural gas firing and illustrates nonuniform firing from opposite sides of the tank, as well as progressive change in firing rates with a continuation of firing in one direction.

Progressive changes in temperature both along the fuel piping and at the burner ports cause the changes, which can be entirely eliminated when control is on the basis of flow measurement. An usually good control of

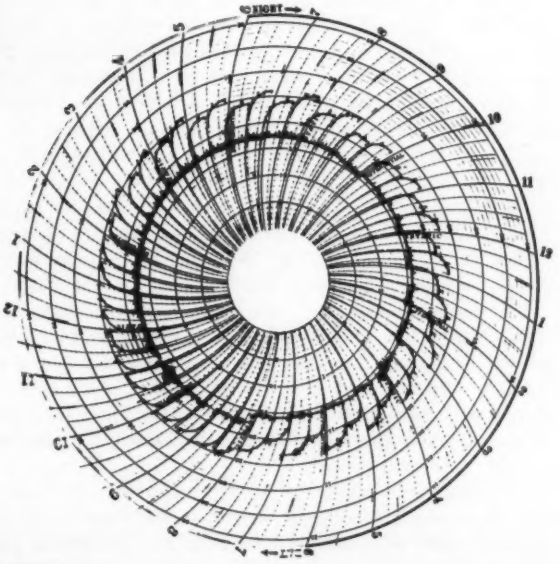


FIG. 6.

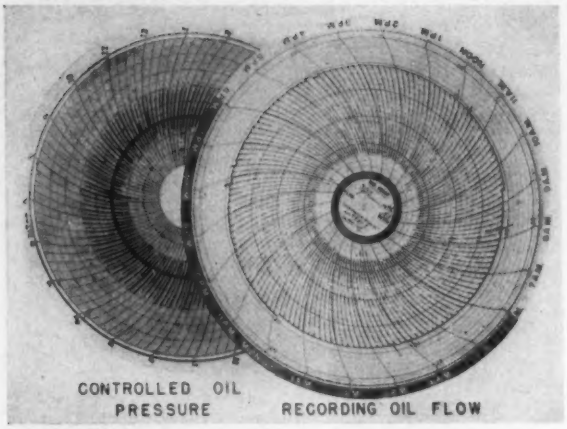


FIG. 7.

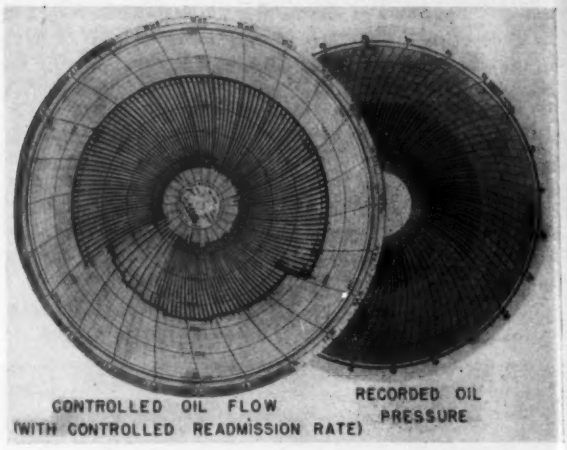


FIG. 8.

oil flow to an end-fired tank by means of pressure is illustrated in Figure 7.

A later installation of control from flow measurement is shown in Figure 8, illustrating an improvement in quality of control as well as the resultant pressure variables required to maintain constant flow rates.

Where multiport firing is employed, direct control from fuel flow should be supplemented by a downstream pressure measurement to indicate burner clogging conditions. This unit is preferably equipped with a signalling system which calls attention to faulty burner conditions.

Having established constant fuel rates, the next step, where air supply fans are used, is to meter the combustion air. This may be accomplished by an independent air control as shown in Figure 1, or by fuel-air rationing and control equipment. Since fuel rates to continuous glass tanks are normally changed only within narrow limits, and at infrequent intervals, the first mentioned method is entirely practical and the equipment costs are materially lower.

To assist the tank teaser, the air flow control meter can also be calibrated with a second scale in terms of fuel flow. Regardless of whether independent or ratio controls are employed, the most efficient settings must be periodically established by means of exit gas analysis. In order to accurately control air volumes, the metered air must be stabilized as to its condition, whether controlled by individual or ratio means. The temperature of air as metered is the highly predominant variable.

Frequently overlooked is that a change in air temperature from 0 to 100° F. representing a seasonal change, causes more than a 10 per cent change in pounds of oxygen delivered through the metered control system.

The simplest and most practical means of correcting this condition (see Figure 1) is by automatic blending of hot air drawn from under the tank, around the burner ports or reversal valves and stack system. This simple device will do more to stabilize day-to-night and seasonal effects upon combustion efficiency than any other similar small investment.

The automatic regulation of air volumes from a continuous analysis of oxygen content in the waste gases is the end goal in combustion regulation. Developments in sampling and oxygen analyses equipment requiring less maintenance and attention will undoubtedly be forthcoming in the future.

Heat Transfer Efficiency

The efficiency of heat transfer within the tank structure proper, while firing intermittently from either direction, is an important phase of the fuel problem. Furnace pressure regulation, as previously described, determines flame distribution and rate of flame propagation.

For liquid fuels, the atomizing pressure (or preferably flow) of atomizing air or steam should be accurately controlled. This can be done by systems similar in principle to those used both for fuel and combustion air flow control. Radiation measurements on certain types of burners have shown that the radiating power of the flame within the furnace can be decreased by 10 per cent with as little as 10 pounds deviation in atomizing steam pressure. Automatic control of liquid fuel temperatures, as fired, is important, not only for accuracy of flow metering but also for securing the best heat transfer in the combustion chamber.

Oil viscosity measurements and control through the resetting of oil temperatures is receiving increased attention due to fluctuations in oil supplies. However, the associated problem of specific gravity as it affects heat transfer and release should not be overlooked in these control refinements which are still in the development stage.

The temperature of the preheated air as it leaves the burner port has a very material effect on the radiating power of the flame and, therefore, the heat transfer to the glass bath. The establishing of 110° air temperature at the combustion fan instead of the 53½° average means temperature represents an additional b.t.u. input into the furnace structure which is equivalent to one per cent of the theoretical heating value of the corresponding oil fuel. As far as direct heat transfer to the bath is concerned, gas temperatures leaving the work chamber and entering the checkers represent losses.

These references to temperature conditions existing in the top of the checker chamber call attention to another form of measurement made practical by modern improvement in radiation elements. An average measurement of the top checker courses, by means of radiation, supplies

many operating guides which are not available in the conventional measurement of exit flue temperatures. During the heating cycle this measurement shows the maximum temperature to which the checkers are subjected, and any flame carry-over is immediately detected. This calls attention to the need for adjusting the fuel rates or burners on the opposite side of the furnace.

During the preheating cycle, the same measurement gives the nearest practical approach to the air preheat temperature with its important effects upon combustion and radiating power.

An installation, showing average top-checker measurements, is illustrated in Figure 9. A Radiamatics installation for this service, with air-cooled fittings and continuous air purge, is shown in Figure 10.

Heat Transfer During and Immediately Following Reversal

The heat transfer conditions which exist during and immediately following reversal have greater possibilities of improvement through automatic action than are to be found in any other part of the firing operation.

A high-speed record of bridge-wall temperature, illustrated in Figure 11, stresses the extremely rapid loss of temperature in the entire furnace structure and also the length of time required to regain that temperature to the required working heat head above the glass bath.

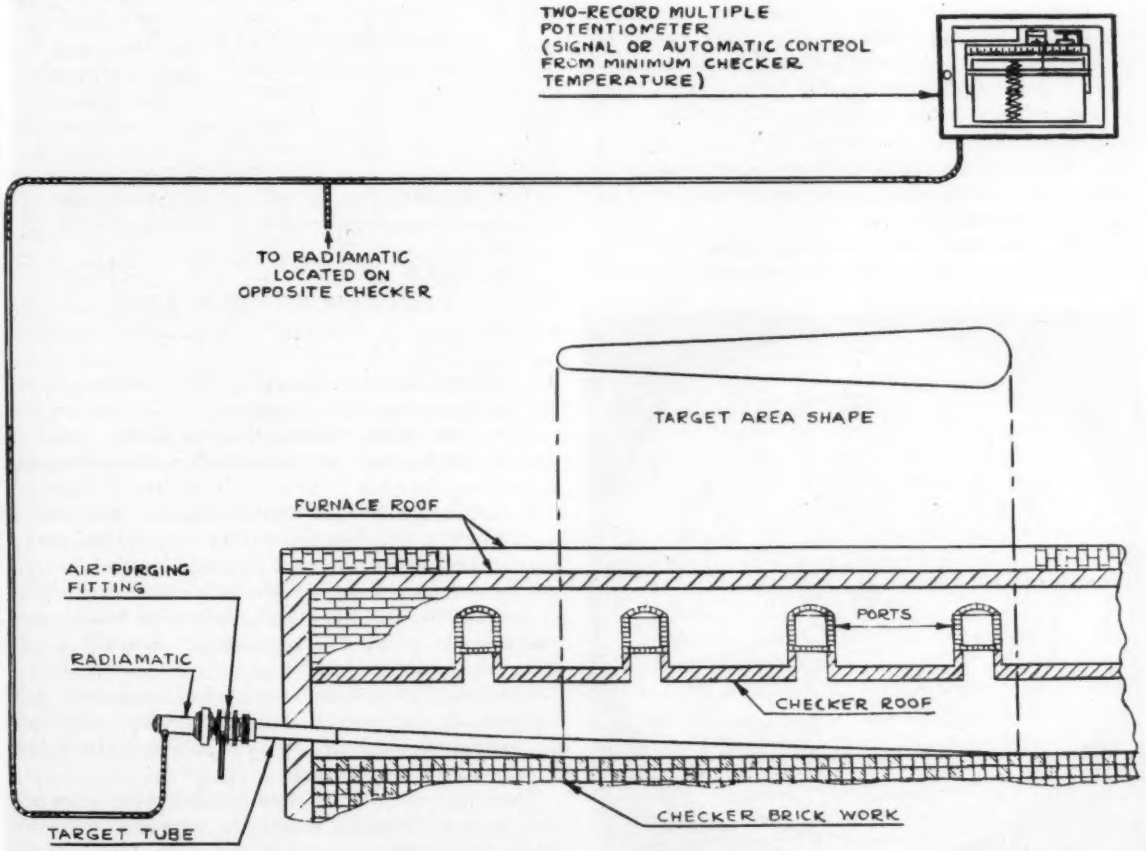
The seconds, even fractions of seconds, consumed in reestablishing good combustion from the oncoming burner ports require almost corresponding minutes to regain the losses in structure temperatures. This emphasizes the desirability of completing the reversal operation in the shortest possible time.

Several automatic but artificial actions can be performed by the control systems to speed up this action, wherever preheating of fuels such as producer gas is not employed.

The first point of attack involves the earliest possible delivery of air for combustion to the oncoming burner port. Several artificial actions can assist in accomplishing this aim. First, the reversal of waste gas and air dampers should be completed as rapidly as possible after fuel shutoff. Second, the furnace pressure control, if allowed to operate normally, initially closes the stack damper and then must open in order to relieve the high pressure condition caused by reversal of the gases through the combustion chamber.

Air delivery to the oncoming burner port is retarded as long as this high pressure exists. Two corrections, initiated from the fuel reversal valve, can be employed to help; either the stack damper can be locked in position during "fuel off" periods or, in the case of a pneumatically operated system, the damper can be artificially opened at a controlled rate during reversal to shorten

FIG. 9.



RADIAMATIC PYROMETERS MEASURING GLASS TANK CHECKER TEMPERATURES

FIG. 10.

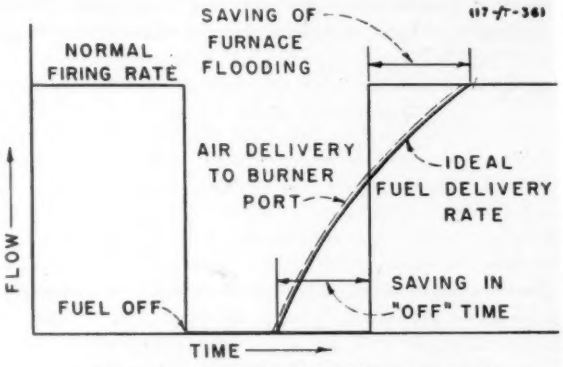
and decrease the high pressure condition. This action also helps to maintain a constant level in the forehearths, the advantages of which have been previously described.

The third artificial action, also initiated by the fuel reversal valve, consists of opening the combustion air damper which allows the forced air fan to deliver its full capacity to the oncoming burner port. Similar actions can also be applied to purging and atomizing mediums for liquid fuels.

Having done everything possible to speed up air delivery, it then becomes important to establish the fuel readmission rates to correspond to the rate at which air can be delivered to the burner ports. Figure 12 illustrates the ideal timed action on fuel readmission rates for decreasing fuel off-time while avoiding flooding of the combustion system. The interlocking of this artificial system with fuel reversal valves and stack reversal valves, Figure 1 (applicable only to the make of instrument shown), provides automatic action and insures proper direction of firing before fuel can be readmitted.

The application of such artificial systems in glass tank firing has reduced the conventional period of approximately 45 seconds between fuel-off and reestablishment of good combustion conditions to intervals of 10 seconds or less. This has resulted in fuel savings of from 3 to 8 per cent in addition to providing an approach to continuous firing and the ability to efficiently increase the frequency of reversal.

The determining of the most efficient frequency of reversal is closely associated with the speed of its performance. Material on this subject has been previously published in considerable detail. Briefly, the more frequent the reversal the higher are the percentage losses due to reversal, but better heat transfer is maintained during each firing period due to eliminating



FUEL READMISSION RATES FOLLOWING REVERSAL

FIG. 12.

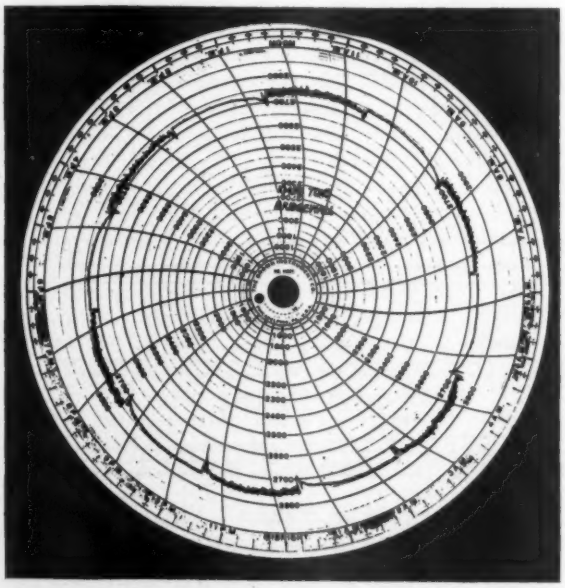


FIG. 11.

low preheat temperatures, as well as avoiding excessive checker refractory temperatures.

Since the checker temperature conditions found in continuous glass tank operations are inherently balanced, reversal on the basis of time, as illustrated in Figure 1, is practical, simple and effective. Signals from efficient maximum and minimum top-checker temperatures should be used progressively to reset the timed interval throughout the weeks and months of tank life, because the ability of the checker system to absorb and release heat changes progressively as the checker structure becomes glazed or covered with batch carryover.

Infrequent reversals can be efficient on a new tank, but must be increased in frequency whenever the final air preheat is insufficient to provide the required heat transfer within the furnace.

The actual reversal operation may be performed manually from a signalling system, or completed automatically. The sizable expense involved in completely mechanizing the reversal operation may be justified whenever

(*Continued on page* 174)

RECOMMEND NO CHANGE IN MINIMUM WAGE FOR PRESSED AND BLOWN GLASSWARE INDUSTRY

On February 9 at the minimum wage hearings before the Wage and Hour and Public Contracts Division of the U. S. Department of Labor, H. L. Dillingham, Secretary of the American Glassware Association, made the following statement recommending that no change be made at this time in the prevailing minimum wage in the Pressed and Blown Glassware Industry.

Mr. Dillingham stated, "I am speaking on behalf of the 43 manufacturers who comprise the membership of the Association. The Association represents about 80 per cent of the dollar sales volume at factory level and approximately 40 per cent of the total number of manufacturers that are engaged in the production of ware included in the Pressed and Blown Glassware Industry as defined by the Wage and Hour and Public Contracts Division of the U. S. Department of Labor for purposes of establishing a minimum wage.

"Many of our members are also members of the National Association of Manufacturers of Pressed and Blown Glassware whose postion in regard to the prevailing minimum wage which should be declared for industry has been presented to you.

"When Congress passed the Walsh-Healey Act, it evidently believed that wages, hours and working conditions of employees should be improved. This was in 1936 before the passage of the Fair Labor Standards Act. Then members of Congress were so firmly convinced of this that they passed the Walsh-Healey Act requiring government contracts for more than $10,000 to be placed with companies which would comply with stipulated conditions outlined in the Act. The Congress evidently felt that the government should assume leadership in the matter of improving working conditions by making its purchases only from companies which complied with certain requirements for the welfare of their employees. Since the passage of the Walsh-Healey Act, Congress has continually been enacting legislation to improve the economic status of workers and now one of the principal functions of the Walsh-Healey Act is to declare a prevailing minimum wage for government contracts of $10,000 or more. These numerous Congressional labor acts have applied to all products which enter into interstate commerce.

"Both the Walsh-Healey Act and the prevailing Congressional act now in force, and the Taft-Hartley Law have the same objectives, namely to secure fair wages, hours and working conditions for employees. All of these labor acts encourage wage conferences between management and workers to establish minimum wages, hourly rates of pay, hours of employment, suitable working conditions and other pertinent regulations which will be fairly reflected in a contract for specified periods. Many times there are provisions under suitable conditions for reopening negotiations to adjust matters in the contract before it has expired.

"Unless the wage minimums in both of these acts coincide, double standards are created which disturb both employees and employers. It seems that now is the time for less confusion in labor relations instead of adding to it by maintaining double standards to regulate rates of pay. These double standards not only confuse workers and management but tend to confuse inspectors of the Labor Department who are empowered to enforce the requirements of both acts. It results usually in establishing a double inspection service to enforce these acts, though they have approximately the same objectives. Unnecessary expense results which should be avoided particularly at a time when Congress and the Labor Department recognize the necessity of reducing governmental operating expense.

"Each year the pressed and blown glassware manufacturer and their employees meet in labor conference and agree to a contract to govern wages and working conditions for the ensuing year. Minimum wages for all employees are set.

"This section of the glassware industry is about 95 per cent organized under the American Flint Glass Workers Union, an affiliate of the American Federation of Labor. Only a very few companies in the industry are not bound by the contract developed each year at the conference. These few companies, however, when making their labor contracts with their employees for their individual plants must of necessity very closely conform to the wage minimums and working conditions appearing in the A.F.G. W.U. contract. If they do not conform and their managements foster a lower minimum wage, their employees will seek employment in glass factories which pay the higher wages.

"This yearly union contract in reality actually becomes an industry standard. The only purpose then of trying to get a higher minimum wage established in the Walsh-Healey Act than is agreed to in the union contract is to have the Walsh-Healey declared prevailing minimum wage, act as an elevator to the minimum established in the union contract. By compiling wage statistics which include not only union contract standard wages per hour, but also premiums paid for increased production and any other incentive bonuses except time and a half for overtime, a prevailing minimum wage is developed which is of course higher than the minimum wage established in the union contract, since this statistical wage level includes payments of incentive premiums.

This higher minimum wage then is presented as evidence complying with the requirement of the Walsh-Healey Act which directs the Department of Labor to survey the industry and declare the prevailing minimum wage.

"In our opinion this is a shrewd maneuver and does not come within the intent of the Congress when enacting the law. It is our belief that a loose wording in the Act obscures the real intent that Congress had namely, to establish a minimum rate which was a standard within the industry as would be evidenced by the prevailing minimum rate established in a contract with an accredited labor organization and agreed to by a large majority of the industry.

"To establish a prevailing minimum wage which re-

(*Continued on page* 172)

RECENT TRANSLATIONS OF RUSSIAN PAPERS OF INTEREST TO THE GLASS INDUSTRY

Abstracts of two papers which appeared in the Russian journal of the glass and ceramic industries.

Silvering of Mirrors

E. S. Nifontova and G. V. Pototskaya lowered the expenditure of silver nitrate in the manufacture of mirrors in their glass plant by 25% as a result of the following series of experiments, described in *Steklo i Keramika* (Glass & Ceramics) 1948, No. 8, p. 8.

1) The thickness of the silver film. Six groups of mirrors, the thickness of the silver film in which ranged from 0.038 to 0.438 micron (or from 0.4 to 4.6 g. per sq. m.), were stored for a year. The 4 groups having thin films comprised, after the storage, damaged specimens, whereas as 2 groups containing thicker films were all undamaged. The minimum thickness precluding damage was 0.23 micron (or 2.4 g. of silver per sq. m.).

2) The silvering solution. This solution was made by adding to 22 liters of water one, two, three, four or five portions of alkaline silver solution. Each portion consisted of 325 cc. 10% KOH, 50g. $AgNo_3$ and 100 cc. 20% NaOH. The reducing solution was made up by dissolving 1000 g. cane sugar and 36 cc. 10% sulfuric acid in 14 liters of water. For every 100 g. of the silvering solution, 5 g. of the reducing solution were used.

The thickness of the silver film remaining on glass increased with the silver concentration in the silvering solution, but the increase was slow and thickness reached only 0.16 micron at the highest concentration tested. Therefore it was decided to use multiple silvering.

3) Multiple silvering. When a silver film was deposited on glass, the mirror obtained was brought in contact with another volume of the silvering solution, a second silver film was deposited on top of the first, and so on, the film thickness grew in steps 1.00-1.75-2.50 and so on. The thickness achieved after the second deposition when 3 portions of alkaline silver solution were used, was about equal to the thickness required. Therefore, the solution recommended consisted of 975 cc. 10% KOH, 150 g. $AgNO_3$, 300 cc. 20% NaOH and 22 liters of water; and it was used twice.

4) The duration of each deposition was 5 to 6 min. as the film ceased to grow after this time.

5) The temperature at which the above experiments were carried out was about 25°C. (77°F.). At lower temperatures the deposition required more time, and above 40°C. (104°F.) the film ceased to be uniform. Hence, the temperature of 25°C. (77°F) was recommended.

Calcium Fluoride in Fourcault Batches

Addition of calcium fluoride (fluorspar) to the batch of Fourcault furnaces was tested in 1947 in several Russian glass plants. A report on this work by D. L. Gik, I. D. Tykachinskii and L. I. Zingman appeared in *Steklo i Keramika* (Glass and Ceramics) 1948, No. 1, p. 4.

For the first experiment a furnace was used which was intended to be closed down for repair within 3 weeks. However, its performance was so much improved by addition of CaF_2 that the repair was postponed for over 2½ months.

The composition of the glass before the experiment was SiO_2 71.7, Al_2O_3 0.7, Fe_2O_3 0.2, CaO 7.6, MgO 3.0, Na_2O 16.3, SO_3 0.5. The glass composition after the addition of CaF_2 is not reported. The composition of the batch is not given except for the statement that 70% of the Na_2O was introduced as Na_2CO_3 and 30% as Na_2SO_4.

Table I shows the results obtained. There were 7 periods. Period I includes 6 months previous to the experiment. Period II lasted 7 days, and the amount of calcium fluoride added was 0.5% of the batch. The duration of every period and the addition of CaF_2 are listed in the table. The performance is characterized by

TABLE I

Effect of calcium fluoride on the performance of a Fourcault furnace

Period	Duration	CAF_2	A	B	C	D
I	6 months	0	577	37.1	28.2	49.0
II	7 days	0.5%	682	37.1		
III	8 days	1.0%	692	41.8		
IV	13 days	1.25%	585	36.9	29.4	55.0
V	10 days	1.0%	607	41.5		
VI	31 days	1.0%	727	45.2	34.4	76.2
VII	30 days	1.0%	653	43.0	32.6	72.5
III-VII	92 days	1-1.25%	696	43.2	32.4	67.9

A the amount of glass (in kg.) produced per sq.m. of the furnace per day.

B the amount of batch (in metric tons) introduced within 24 hrs.

C the area of glass sheet (in sq.m.) produced by a Fourcault machine per hour.

D the area of glass sheet (in 1000 sq.m.) produced by the furnace per month.

The poor performance during period IV is attributed to the difficulties experienced by the producer gas system and not to an unfavorable effect of the higher (1.25%) concentration of calcium fluoride. Otherwise, the improvement due to calcium fluoride is unmistakable.

An improvement was visible also on direct observation of the molten glass. The length of the glass surface free of scum increased by 2 to 2.5 m. (about 7 to 8 ft.) when the calcium fluoride addition was 1% or 1.25%. The working properties of the glass changed so much that the temperature in the middle of the Fourcault channel had to be lowered by 15°C. The number of air bells and other inclusions in the glass was significantly reduced.

Table II shows the effect of calcium fluoride on the performance of 2 other furnaces which were in a better

(*Continued on page* 177)

INVENTIONS AND INVENTORS

A Summary of Recently Issued Patents of Interest to the Glass Industry

Furnaces

Port for Glass Tanks. Fig. 1. Patent No. 2,460,514. This invention was made by Levi S. Longenecker of Mount Lebanon, Pa. According to the patent, it has previously been unsatisfactory to introduce high velocity liquid fuel into the air stream from the checkers near the pool of molten glass. The tendency was to create hot spots in the glass or to burn out the refractories.

Fig. 1 is a section through a port of a tank showing the bottom 10 and side wall 11 which form a chamber 12 containing the molten glass 13. One of the ports is shown which takes preheated air from a regenerator 16 through an uptake 20, all about as in the usual construction. The particular feature of this invention is in the knuckle-like roof comprising the parts 24, 25 and 26. Reference is made to patents No. 1,590,303, 2,126,901 and 2,240,190, all by the same inventor, for details of construction.

A high velocity fuel jet 35 is positioned so that the liquid fuel mixes with the preheated air adjacent the face of the block 23. The position of the knuckle may be varied somewhat and, of course, the furnace is reversed as usual. However, the result is that no hot spots are formed on the surface of the glass and the burner is readily accessible for servicing.

The following references are of record in the file of this patent: United States Patents: 1,637,473, Culbertson, Aug. 2, 1927; 1,653,507, Pike, Dec. 20, 1927; 1,893,061, Peiler, Jan. 3, 1933; and 2,300,426, Longenecker, Nov. 3, 1942.

Glass Wool and Fiber

Orifice Plate Material. Fig. 2. Patent No. 2,460,547. Charles R. Stevens of Toledo, Ohio, made this invention and assigned it to Glass Fibers, Inc., of Waterville, Ohio. In drawing fibers of a diameter of .00025 to .00035", it is desirable to use a metal for the orifice which will not be wet by the molten glass. If this is not done, imperfect fibers are produced. This invention solves the problem

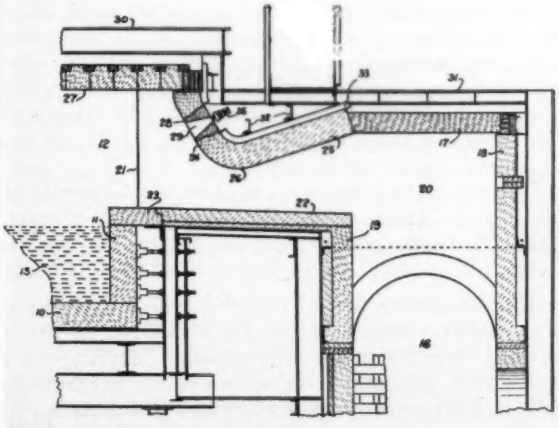


Fig. 1. Port For Glass Tanks.

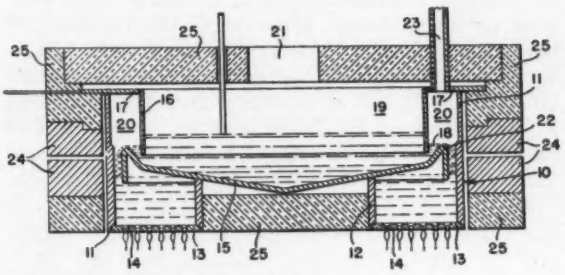


Fig. 2. Orifice Plate Material.

by proposing a metal for the orifice comprising, in part at least, a platinum-rhodium alloy consisting of at least 40% rhodium.

In Fig. 2 there is shown a heating crucible 10 having inner and outer walls 11 and 12. Between these walls there is an orifice plate 13 having orifices 14 and above this there is a dish-shaped member 15 which cooperates with a cylindrical wall 16 to form a trap 18. Glass material is introduced into the melting chamber 19 through an opening 21 and the molten glass flows over the edge of the member 15 into the drawing chamber.

Gas under pressure is supplied to the drawing chamber 20 by a pipe 23 and this pressure aids in forcing the molten glass out through the orifices 14. The glass is heated by coils 24 to maintain its molten state.

The orifice plate 13 is made of a platinum-rhodium alloy having a rhodium content of at least 40%, the remaining part being platinum. This composition will not be wetted by the molten glass which results in the elimination of many difficulties heretofore encountered in drawing glass fibers.

The following references are of record in the file of this patent: United States Patents: 1,850,818, Waltenberg et al., Mar. 22, 1932; 1,990,277, Feussner et al., Feb. 5, 1935; 2,031,083, Weller, Feb. 18, 1936; 2,165,318, Thomas et al., July 11, 1939; 2,188,636, Vilensky, Jan. 30, 1940; 2,190,296, Richardson, Feb. 13, 1940; and 2,239,561, Hopps, Apr. 22, 1941. Foreign Patents: 3,174, Great Britain, Dec. 28, 1857.

Method of Making Fibers. Patent No. 2,461,841. Martin E. Nordberg assigned this patent to Corning Glass Works. It relates particularly to the treatment of glass fibers whereby non-siliceous constituents are removed by a leaching process to produce a highly siliceous fiber having improved characteristics. This patent provides a method of making fibers from a glass of new composition and by a new method which has high chemical durability, particularly toward acids, has high absorptive capacity and is highly porous, as well as possessing many other desirable qualities.

The fabric made in accordance with this patent is soft to the touch, has high heat resistance and makes an excellent substitute for asbestos. It is stable at temperatures above 400°C., and is particularly useful in filters.

The general idea of the invention may be obtained

from the first claim of the patent which is as follows: The method of making an article composed of refractory glass fibers which comprises melting a silicate glass containing not more than about 75% SiO_2, and at least one additional glass forming oxide of a metal of the second, third or fourth periodic group selected from the class consisting of beryllium, magnesium, calcium, zinc, strontium, cadmium, barium, boron, aluminum, titanium, zirconium, and thorium, forming the glass into fibers having a diameter not exceeding about .001 inch, and fabricating the fibers into an interlaced arrangement to form a fabric, leaching the fabric with an aqueous solvent having a pH not greater than 7 to extract non-siliceous constituents and leave a porous highly siliceous residue.

The following references are of record in the file of this patent: United States Patents: 1,721,979, Taylor, July 23, 1929; 2,184,320, Simpson, Dec. 26, 1939; 2,215,039, Hood et al., Sept. 17, 1940; 2,221,709, Hood et al., Nov. 12, 1940; 2,286,275, Hood et al., June 16, 1942; 2,338,463, Skaupy et al., Jan. 4, 1944; and 2,339,928, Hood, Jan. 25, 1944. Foreign Patents: 504,883, Great Britain, May 2, 1939.

Miscellaneous Processes

Method of Strengthening Glassware. Patent No. 2,459,209. This patent is the invention of Theodore K. Zagwyn of Waltham and Peter R. Kosting of Belmont, Mass. The patent starts out by stating that the invention claimed may be used by or for the Government without the payment of any royalty to the inventors. The patent sets forth a method of improving the physical properties of shaped articles of glass or quartz after it has passed through a molten condition.

Vitreous fused silica referred to in the patent is sold under the trade name of "Vitreosil" by The Thermal Syndicate, Limited, Brooklyn, N. Y. and Wallsend-on-Tyne, England. The invention is particularly useful in connection with tubes of vitreous fused silica having one closed end and used as a radiation source in contact with molten iron at high temperatures which may be around 2800 to 3100°F. Heretofore such tubes have failed after one or two immersions. The life of these tubes is greatly increased, according to this patent, by heating the tube before use to a temperature between 2500 and 2750°F. and holding it at this temperature for a period of from five to thirty minutes and then cooling it to about 1800°F. before immersion in the molten metal. This treatment increases the life of the tube up to twenty times over what has been usual.

The following references are of record in the file of this patent: United States Patents: 1,628,468, Miller, May 10, 1927 and 2,270,718, Skaupy, Jan. 20, 1942.

Machine for Making Spiders for Electric Lamps. Fig. 3. Patent No. 2,459,513. John Flaws, Jr., assigned this patent to General Electric Company. These spiders are made by forming buttons on a glass tube and inserting radial wires in the buttons to support the filament. The invention provides an automatic machine for forming the buttons in any desired spacing relation along the tubular arbor.

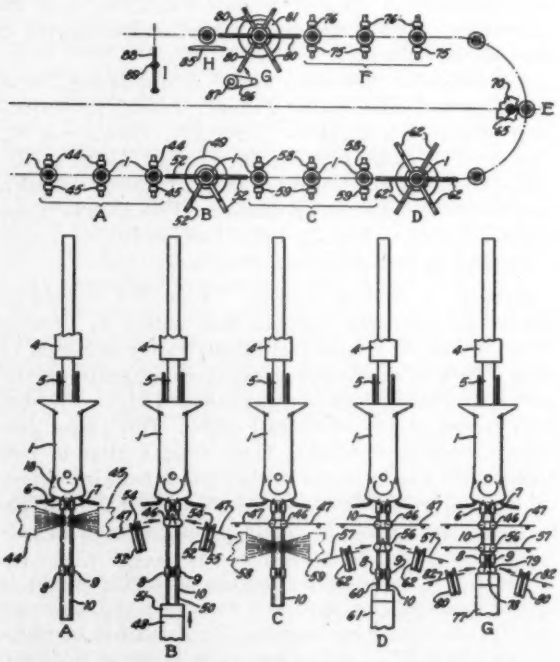


Fig. 3. Machine for Making Spiders for Electric Lamps.

The upper part of the figure is a diagrammatic plan and the lower part shows the operations which take place at the several work stations. Lamp stems 1 are supported by heads which are advanced to the work stations in about the same way shown in the earlier patent to Flaws, No. 1,907,532. The stem is gripped and supported by jaws, one of which is shown at 4 engaging the exhaust tube 5 and jaws 6, 7, 8 and 9 which engage the tubular arbor 10. The chucks are arranged to advance the work to a number of stations where the several operations are performed.

At station A, a portion of the arbor 10 adjacent to the jaws 6, 7 is heated to the softening point by burners 44 and 45. At the next station B, the softened portion is formed into a button 46 and support wires 47 are inserted into the button. Support wires 57 are added at later work stations, C and D. Rams 62 are arranged to insert the wires around the buttons at 60° intervals. At station C the arbor is heated by burners 58 and 59. Station C is really three work positions as shown in the upper figure. At station D a pointed mandrel 60 keeps the arbor open and the button is formed by the upward movement of the rod 61.

At station E the jaws 8 and 9 are repositioned, which is made necessary by the shortening of the tube. The next four stations are indicated at F and G where the tube is heated by burners 75 and 76 and wires are inserted by rams 80. The completed spider is removed at station H and at the following station I, the jaws 8 and 9 are repositioned for the next cycle.

The following references are of record in the file of this patent: United States Patents: 1,663,550, Higgins, Mar. 27, 1928; 1,698,321, Staudenmeier et al., Jan. 8, 1929; and 1,907,532, Flaws, May 9, 1933.

Glass-containing Ceramic Body. Patent No. 2,460,356. This patent relates to a process of forming a strong ceramic body by molding dry powder, including glass, under high pressures. The inventors are Ekkehard L. Kreidl and Joseph L. Utter, who assigned it to Arthur D. Little, Inc., of Cambridge, Mass.

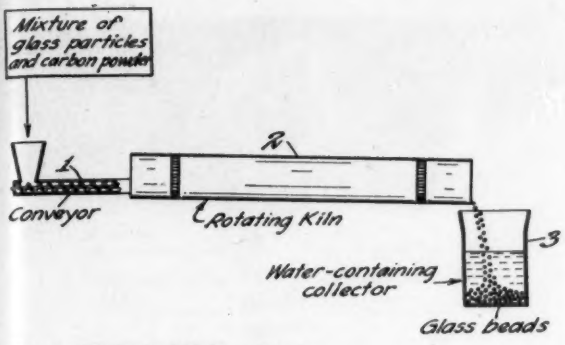


Fig. 4. Method of Making Beads.

Suitable material for use in this process is described in Patent No. 2,362,430 to Martin J. Buerger and an application filed in 1946, which apparently has not yet issued as a patent. These materials are known as "plastically deformable". The process of the patent is carried out by molding a mixture of finely inorganic refractory material and at least 2% by weight of a powdered glass having a melting point which is less than the fusion temperature of the refractory material under a pressure of at least about 5 tons per square inch, firing the molded structure, cooling, impregnating the structure with an inorganic gel produced from a partially or completely hydrolyzed compound of an inorganic oxide having glass forming characteristics, and refiring.

It has been found that calcium fluoride (fluorite) is a satisfactory refractory material and that lead borate makes a good low melting glass. The patent should be studied by anyone interested as it gives detailed instructions for carrying out this process so as to obtain a product much superior to those heretofore known.

The following references are of record in the file of this patent: United States Patents: 2,286,275, Hood et al., June 16, 1942; 2,315,329, Hood et al., Mar. 30, 1943; 2,340,013, Nordberg et al., Jan. 25, 1944; and 2,355,746, Nordberg et al., Aug. 15, 1944.

Method of Making Beads. Fig. 4. Patent No. 2,460,977. This is the invention of Edward P. Davis and Harry Heltzer, who assigned it to Minnesota Mining & Manufacturing Company of St. Paul, Minn. The beads made according to this patent are small spherical balls such as used in the manufacture of motion picture screens, reflex reflecting signs, road markers and so forth. In order to get the best results, it is desirable that the beads be as nearly perfect spheres as is possible.

The method of this patent as set forth in one of the claims, comprises heating a mixture of glasss particles and carbon powder sufficiently to cause combustion of the carbon powder and fusion of the glass particles into non-adhering spheres formed by surface tension, and terminating the heating and combustion to avoid coalescence of the spheres, and then cooling the spheres, the proportion of carbon being sufficient to prevent the spheres from sticking together.

Fig. 4 is a diagrammatic flow sheet showing how this process is carried out. A mixture of glass particles and carbon powder is fed to a screw conveyor 1 by which it is delivered to a rotating kiln 2. The beads and remaining carbon particles fall into the water bath 3. The glass particles may be pulverized cullet from almost any kind of glass. This is graded so as to obtain particles of the right size to make the desired size beads but, of course, the finished beads may be sorted for size also. The size of the beads to be made varies widely but the greatest demand is for beads having a diameter of from 3 to 60 mils. For instance, beads of from 3 to 10 mils in diameter are used in making reflex reflector signs as described in Patent No. 2,354,049.

The number of beads of this size, as compared to volume, is surprising. For example, a cubic foot of beads of 10 mils diameter would amount to about two thousand million (two billion) beads.

"Carbon" as used in this patent includes graphite, lamp black and various other carbon mixtures all of which should be pulverized to a fine powder. The proportion of carbon to glass will vary considerably in accordance with conditions, but it will be found that somewhere between 10 and 100 parts of carbon to 100 parts of glass will be satisfactory. The temperature of the kiln will vary in accordance with the glass being used, but with a soda-lime-silica type, the temperature will be around 900°C.

After cooling, the beads may be cleaned by washing in a hot solution made up as follows:

	Parts by weight
Glass beads	1,000
Water	850
Trisodium phosphate	16
Ammonium chloride	0.2
Soap	0.3
Pine oil	1

This patent calls attention to Patent No. 2,461,011 to Taylor and Murray for more detailed claims, which patent is reviewed in the next abstract.

The following references are of record in the file of this patent: United States Patents: 2,123,536, Long, July 12, 1938 and 2,332,361, Anastor et al., Oct. 19, 1943.

Method of Making Beads. Fig. 5. Patent No. 2,461,011. This invention, like the preceding one, was assigned to Minnesota Mining & Manufacturing Company. The

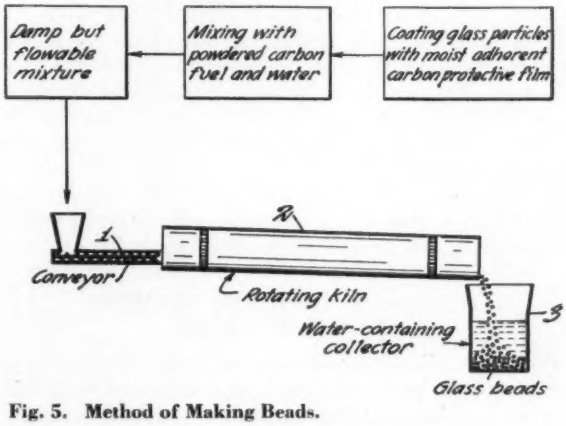


Fig. 5. Method of Making Beads.

inventors of the patent are Nelson W. Taylor and Robert C. Murray. The general object of the two patents is the same; that is, the manufacture of small solid balls of glass commonly known as beads.

(*Continued on page* 178)

GLASS BOTTLE BLOWERS A.F.L. DEFEAT C.I.O. RAIDS ON GLASS CONTAINER INDUSTRY

The Glass Bottle Blowers Association of the United States and Canada has been meeting with great success in combating the attempts of the C.I.O. Glass Workers Union to raid the A.F.L. affiliate.

The C.I.O. Glass Workers Convention last summer adopted a resolution that was intended to destroy the Glass Bottle Blowers Association. The C.I.O. union actively engaged in an organization drive which was centered on both the East and West Coasts.

The Glass Bottle Blowers Association has answered this threat by overwhelmingly defeating the C.I.O. in two elections. By a majority of three to one the members of the Glass Bottle Blowers Association retained their affiliation with the A.F. of L. The companies involved were the Armstrong Cork Company at Millville, New Jersey and the Ball Brothers Glass Company at El Monte, California.

U. S. COURT OF APPEALS REVERSES DISBARMENT RULING

The United States Circuit Court of Appeals at Washington has reversed a 1944 ruling which disbarred three prominent glass industry attorneys. An attempt to have the ruling reversed in 1947 was refused.

The attorneys involved are Henry W. Carter, retired Vice President and General Counsel of Owens-Illinois Glass Company; Roswell F. Hatch, 66, Hartford-Empire Company; and Vernon M. Dorsey, 70, Washington patent attorney. The action against these attorneys resulted from the testimony given in the government's antitrust suit against the glass container industry which started in Toledo in 1941. It was charged that the attorneys had conspired to work a fraud on the Patent Office in 1926 through the use of a ghost-written article in an effort to obtain a patent.

In reference to the Patent Office committee which found the attorneys guilty of misconduct, the court stated that "both the charges and the findings are so confused that it is difficult to determine just what any of the defendants were charged with or convicted of."

In conclusion, the court said that plenty of judges and statemen have used "ghost writers" and that "the test should have been the truth or falsity of the facts set out in the article and we do not understand that the truth of these statements has been called into question in any quarter."

While the final appeal was made only in the name of Attorney Dorsey, the appeals court's opinion generally covered the whole disbarment matter.

PENNSALT APPOINTS DISTRICT SALES MANAGER

Donald W. Graham has been appointed District Sales Manager of the Heavy Chemicals Division of the Pennsylvania Salt Manufacturing Company to take charge of the Cincinnati sales office.

Mr. Graham, who has been in charge of the company's St. Louis office for several years, succeeds C. W. Dermitt, resigned. Mr. Graham joined Pennsalt in 1932 and became a salesman for the Heavy Chemicals Division at Chicago in 1935, and transferred to St. Louis in 1943.

UNION PACIFIC POSTERS AIMED AT REDUCING FREIGHT LOSS AND DAMAGE

Union Pacific Railroad's Freight Claim Department has inaugurated a campaign to reduce freight loss and damage. The effort is based on twelve posters directed to freight handlers, operating men and all others associated with the movement of freight.

O. J. Wullstein, Union Pacific General Freight Claim Agent, who conceived the campaign and under whose direction it is being carried out, pointed out that posters of this nature directed to freight handlers and operating men are not new, that similar material has been distributed from time to time by the Association of American Railroads and also by individual railroads.

"However," Mr. Wullstein said, "our current campaign is the first one of a localized nature and which attempts to build morale and strengthen employee relations as well as educate. Our objective is to go right to the men working with freight. Much has been said to railroad executives and management about freight handling, but all too little to the man on the freight dock, in the yards and the train crew member."

NEW GLASS PLANT TO START PRODUCTION IN TRINIDAD

A glass factory in Trinidad, the first of its kind in the West Indies, is expected to be completed early this year, the Foreign Trade Service, Canadian Government, reports from the Port of Spain.

Experimental melting will first take place and the factory is expected to reach full-scale production by March or April. The glass plant will provide the bulk of containers necessary for local use: bottles of all kinds including jars, cosmetic containers and prescription bottles.

GI Research Digest

Factors in Service Behavior of Silica Brick

In a recent article (*Blast Furnace Steel Plant*, 36 6 701-706 (1948)), L. A. Swift discusses various factors involved in the service behavior of silica brick. Smith divides service behavior factors into groups related to 1) raw materials and aspects of the brick as such, 2) furnace design and such factors occurring between the brick plant and their use and 3) brick in service. The effect of quality of raw materials, grain size, brick molding firing practice and thermal properties of quartz are discussed under 1. Under 2 is discussed handling and storage, the use of mortar which is not known to affect the life of the brick, furnace design to avoid undesirable gas flows and the need for critical review of patching practices, while under 3, design dimensions, bricklaying practices and the influence of method of furnace operation is discussed.

As some of the ideas expressed in this latter part (which, of course, deals with open hearth practice) are of interest to those dealing with glass furnaces, this part of the article is condensed below.

"In many open hearth shops, the mason supervisor and the open hearth superintendent are the 'designers'. They may raise an arch here, lower a neck there, make an end wall thinner or do any number of things which can affect the service behavior of silica brick. The bricklayer and the operator, functioning as designers of open hearths, must not be overlooked as factors in service behavior of silica brick. Then we have the bricklayers functioning as masons, laying brick. The carefulness, skill and 'know how' of the craftsmen who actually build silica brick jobs are just as surely factors in service behavior of the brick used as is the alumina content, the lines of the designer or the zeal of operators to take care of their furnaces.

"In the field between design of the lines, wall thicknesses, buckstays and even selection of the brick and the actual laying of the brick, is that part of the job which sees that the right brick are used, that they are used where they belong and which sees that they are put in right, that proper mortar, if it is a mortar job, is used, that joints are right, that bonds are made, keying is correct and so on. These are some of the bricklayer items discussed with respect to their relation to service behavior of silica brick."

The expansion characteristics of silica brick is on the order of 3/16 in. per linear foot. The designer can indicate overall expansion on his drawings, and may even break it down into ½ inch or ¾ inch gaps every three feet. The bricklayer may follow instructions to the smallest fraction of an inch, but if he carelessly lets spalls or chips lodge in the open joints, or absentmindedly "forces" brick into too many tight fits instead of cutting so that they fit loosely, the provisions for expansion won't function and the wall will likely buckle, "pinch spall" and fail prematurely.

Then there is the matter of bonding. If the job calls for careful bonding (and most silica jobs do), a good bricklayer won't leave "straight" joints nor will he hide them where no one can see. With the excessive expansion movements of silica construction, usually all work must be well bonded to prevent wall cracks which can slab off rather heavy sections at times.

In building sprung arches, the skewbacks must be set right, which means every brick must be solidly against its support as well as in good alignment with the other skewback. This isn't always as easy as it looks, particularly when working with an old open hearth whose structural work may be warped and twisted. If the mason hopes to build a good arch, he must set his skews properly and that may necessitate more and better cutting than he likes to do. If, instead of doing a careful mechanical job, he chooses to use a little extra mud, his arch may weaken just enough to drop a sizable section seriously impairing roof life.

Finally, a bricklayer can build arches with too many squares, or he can use a wrong tapered brick. He can even keep a fairly good radial course with some tapered brick upside down, and he can use mortar generously for a few joints, and perhaps not at all for a few more, to get out of cutting. Often such "jerry-work" doesn't do much, if any, harm, but it isn't recommended and should not be allowed.

One more bricklaying item of considerable importance is the keying practice for open hearth roofs. Cutting costs money, but we think it pays to cut and fit plenty of brick at the crown of an arch so that none will be unduly thin and all will be strong and properly bedded. When keys are driven, there should be at least three, one at the crown and others halfway between the skew and the crown on each side. The keys should be tight, but not so tight that they lift the arch off the center. Arches keyed too tight can, and often do, get into "pinch-spalling" trouble.

It was purposely not tried to cite all the bricklayer factors in the service behavior of silica brick because, in the author's opinion, poor bricklaying is in no sense a major cause of silica brick failures. It is the author's considered judgment, based on at least a fair experience in observing refractories bricklaying, that the chance of poor mason work being the cause of premature failure of silica brick is the exception and not the rule. Most bricklayers will do the kind of a job the boss wants whether he watches or not. However, it is up to the boss to watch and watch critically because, as stated above, any or all the advantages of super brick, best design and good operating practices may be for naught if bricklaying is not right. Bricklaying "know how" is a most important factor in the service behavior of silica brick.

Another important factor is not its quality but the way it is used or, it should be said, the way it is abused during actual operation. For example, heating-up dam-

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age, excessive roof temperatures, plugged checkers, reducing atmospheres, dripping water, misdirected burners, flame defection and roof gouging of "tilted tilters" are some of the more familiar operating factors having to do with service behavior of silica roofs.

It is granted that many legitimate reasons can be cited, and perhaps accepted, in defense of an occasional burn, or a day's run with choked checkers, or even an accident of piled up scrap. However, poor heating-up practices are hardly defensible and while it is possible to have had "bad brick" in one end of a roof, it isn't probable. It is well known that the melting point of pure silica is not much above 3100°F. and that the best silica brick are not pure silica. The operator knows that no matter how he explains it and regardless of whether he sees brick running or not, he is eroding his silica roof when temperature with a favorable atmosphere is above 3000°F. and at an even faster rate and with lower temperatures, if the furnace atmosphere is highly reducing (open hearth operators are concerned with iron-silica reactions in lowering the melting point. The same principle applies to alkali dusts in glass furnace practices).

Heating-up damage, as a factor in roof life, has been mentioned as has also the abnormal thermal expansion behavior of silica brick. Most roofs are heated up safely, but at a cost of too much time and, in the author's opinion, most new roofs can be safely heated up faster than is now generally being done. It would seem the important trick is to see to it that once the temperature build-up in the brick has begun, the process should be kept going, steadily and with recession, slow down or break of any nature, until the hot face is well past 2000°F. Most heating-up damage comes from see-sawing temperature increases rather than from driving heat into the brick too fast, and it is known that brick can be heated too fast. In this respect, a most important phase in heating-up comes with the first reversal when cold checkers sometimes cause a short but damaging chilling of roof brick not yet hot enough to stand a drop in temperature.

On this score, it is a fact that a silica roof at around 3000°F. can be cooled rapidly to 2000°F. and even lower without distress or damage, but the next 1000° drop must be at a very slow rate to be safe. This ability of silica brick to withstand big temperature swings without hurt in their high temperature working ranges is not only a most important factor in their service behavior but that characteristic, coupled with ability to carry heavy loads almost to the melting point along with their cheapness and availability, is what makes them one of the most, if not the most valuable refractory we have.

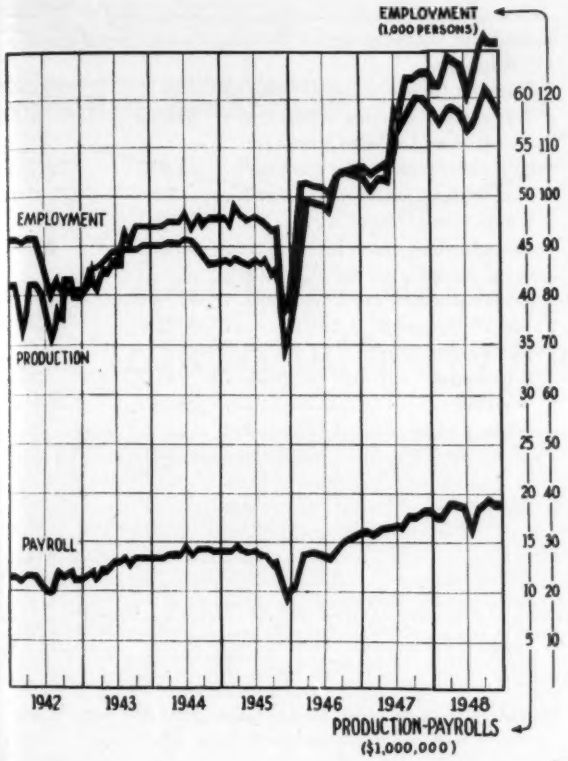
NATIONAL SAFETY COUNCIL RELEASES SAFETY FILMS

A new series of six sound slide films entitled, "Human Factors in Safety", has been released by the National Safety Council to aid management's foreman training program.

The 35 mm., 33½ r.p.m. films comprise a visual training course for foremen that deals with production and job attitudes, as well as safety. Each film deals with one aspect of the complex art of handling people.

CURRENT STATISTICAL POSITION OF GLASS

THE GLASS INDUSTRY'S INDEX



Activity in the glass industry for the month of December 1948, according to the Production Index, increased slightly to reach an estimated $69,500,000. This is not quite 1 per cent above the $69,350,000 reported for the previous month. During December 1947, production was an estimated $64,750,000, which is about 7 per cent below December 1948. Total glass output for the entire year of 1948 has reached an estimated $770,650,000. As compared with the corresponding 1947 estimated figure of $721,000,000, glass output for 1948 was 8 per cent above 1947.

Employment and payrolls: Employment during December 1948 dropped about 2 per cent from the previous month's 121,800 to 118,800. Employment during December 1947 was 119,700.

Payrolls for December 1948 were estimated to be $19,000,000. This is approximately the same as reported for November 1948 since the variation was only about .003 per cent. During December 1947, payrolls were an estimated $18,500,000, or about 3 per cent below December this year. At the close of 1948, glass manufacturers had paid out an estimated $208,000,000 in payrolls. This is about 2 per cent above the $203,500,000 paid out at the close of 1947.

Glass container production for December, based on figures released by the Bureau of Census, closed 1948 with the year's low of 6,764,567 gross. This represents a decrease of about 7½ per cent from the 7,312,507 gross produced during November. During December 1947, production was 7,998,024 gross, or 15 per cent above December 1948. Total glass container production for 1948 is 98,678,857 gross, or about 14 per cent less than the 115,343,858 gross produced during 1947.

Shipments for December 1948, also the lowest for the year, were 6,320,671 gross. During November, shipments were 6,709,720 gross, or about 6 per cent above December. During December 1947, shipments of glass containers were 7,991,488 gross, or 21 per cent above December 1948. The final total for 1948 shipments is 97,332,944 gross. As compared with the total shipments of 110,169,775 gross for 1947, a decrease of 11½ per cent is shown for 1948. *(Continued next page)*

GLASS CONTAINER SHIPMENTS

(All figures in Gross)

Narrow Neck Containers	December 1948
Foods	568,767
Medicinal & Health Supplies	828,597
Chemicals, Household & Industrial	353,502
Beverages, Returnable	247,091
Beverages, Non-returnable	2,876
Beer, Returnable	93,395
Beer, Non-returnable	238,360
Liquors	554,649
Wines	317,373
Toiletries & Cosmetics	392,691
Sub-total (Narrow)	3,597,301
Wide Mouth Containers	
Foods	1,629,904
Dairy Products	280,471
Home Canning	10,934
Medicinal & Health Supplies	244,380
Chemicals, Household & Industrial	63,825
Toiletries & Cosmetics	100,894
Packers' Tumblers	100,813
Sub-total (Wide)	2,431,221
Total Domestic	6,028,522
Export Shipments	274,149
Total Shipments	6,302,671

GLASS CONTAINER PRODUCTION AND INVENTORY

(All figures in Gross)

		Production December 1948	Stocks December 1948
Foods; Medicinal & Health Supplies; Chemicals, Household & Industrial; Toiletries and Cosmetics	Narrow Neck	2,507,443	3,170,892
	Wide Mouth	*2,222,620	1,953,346
Dairy Products		280,333	205,770
Home Canning		.....	749,870
Beverages, Returnable		262,094	624,669
Beverages, Non-returnable		.....	2,847
Beer, Returnable		169,749	762,197
Beer, Non-returnable		289,176	385,162
Liquors		626,871	588,382
Wines		304,045	233,223
Packers' Tumblers		102,236	76,304
Total		6,764,567	8,752,662

*This figure includes "Home Canning."

While stocks for December remained the same on the average, they do show an increase of 5 per cent over November: 8,752,662 gross on hand at the close of December as compared with 8,280,777 gross on hand at the close of November. Stocks on hand at the close of December 1947 were 8,056,859 gross.

Compilation of national totals of glass container production and shipments for January 1949 was not complete when this issue of THE GLASS INDUSTRY went to press. Not all companies had reported.

We regret the omission of this important regular feature. It is likely that the January report will be completed and in our hands by the time this issue reaches readers and it will be published in April.

In the meantime, THE GLASS INDUSTRY will be glad to answer all requests for January 1949 figures. Write, wire or telephone THE GLASS INDUSTRY, Editorial Department, 55 West 42nd Street, New York, N. Y. LOngacre 3-1521.

Automatic tumbler production still continues to drop. During January 1949, production was 4,275,679 dozens. This represents a drop of 11½ per cent from the 4,834,520 dozens produced during December 1948. During January 1948, production was 4,538,969 dozens. Shipments of automatic tumblers also continued on the downgrade to reach 4,293,462 dozens, or 1 per cent below the 4,346,962 dozens shipped during December 1948. Shipments during January 1948 were 4,415,657 dozens. Stocks on hand at the close of January 1949 were 8,694,396 dozens; at the close of December 1948, 8,245,303 dozens; and at the close of January 1948, 8,690,020 dozens.

1948 TOTALS GLASS CONTAINER PRODUCTION AND SHIPMENTS

Narrow Neck Containers

	Production	Shipments
Foods		9,851,931
Medicinal & Health Supplies		11,821,735
Chemical, Household & Industrials		5,728,957
Toiletries & Cosmetics		4,931,193
General Use Total	33,570,841	32,333,816
Beverages, Returnable	8,587,959	7,792,309
Beverages, Non-returnable	16,629	12,807
Beer, Returnable	5,329,090	4,099,518
Beer, Non-returnable	3,819,699	3,565,009
Liquors	8,403,383	7,760,308
Wines	3,301,410	3,182,466
Sub-Total (Narrow)	63,029,011	58,746,233

Wide Mouth Containers

Foods		22,937,533
Medicinal & Health Supplies		3,017,577
Chemical, Household & Industrials		970,109
Toiletries & Cosmetics		1,539,680
General Use Total	28,683,359	28,464,899
Dairy Products	3,365,556	3,247,156
Home Canning	2,193,965	2,117,300
Packers' Tumblers	1,406,966	1,388,635
Sub-Total (Wide)	35,649,846	35,217,990
Total Domestic	.....	93,964,223
Export Shipments	.....	3,368,721
Grand Total	98,678,857	97,332,944

GENERAL STATISTICS FOR THE GLASS CONTAINER INDUSTRY, UNITED STATES TOTALS: 1947 AND 1939

(Money figures and man-hours in millions)

Item	1947	1939
Number of establishments	87	77
All employees:		
Number (average for the year)	47,132	29,357
Wages and salaries (total)	$126.5	$43.0
Production and related workers:		
Number (average for the year)	41,943	25,753
Man-hours (total)	87.5	n.a.
Wages (total)	$107.1	$34.2
Value added by manufacture[1]	$252.1	$98.4
Cost of materials, supplies, fuel, electricity, and contract work	$192.0	$59.9
Value of shipments, total[2]	$422.6	$158.3
Glass containers:		
Quantity (millions of gross)	111.2	n.a.
Value	$415.7	$151.6
Pressed and blown glassware (other than glass containers)	$5.3	$6.7
Other products	$1.6	
Expenditures for new plant and equipment	$32.8	$8.8

n.a. Not available.

[1] For 1947, partly estimated by subtracting cost of materials, fuel, electricity, and contract work from value of production calculated by multiplying quantity produced by unit value of shipments. For 1939, value of production less cost of materials, etc.

[2] Value of production for 1939.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware showed an increase for the first time in several months. Sales for January 1949 were 2,952,703 dozens, or 6 per cent above the 2,785,439 dozens reported for December 1948. Sales during January 1948 were 3,195,459 dozens. At the close of the 12-month period ending January 1949, manufacturers' sales had reached a total of 40,804,566 dozens. This is a drop of .006 per cent from the 41,062,031 dozens sold during the corresponding period ending January 1948.

The figures for automatic tumbler production and sales of table, kitchen and household glassware of one manufacturer are estimated due to this company's inability to meet THE GLASS INDUSTRY's deadline. However, the totals for this concern have been estimated in order to complete the compilation of total industry figures. These total figures will be adjusted in the next issue of THE GLASS INDUSTRY.

NORTON ELECTS DIRECTOR

William R. Moore was elected a director of Norton Company at the 63rd annual stockholders' meeting recently held. Mr. Moore is currently a Vice President of the company.

A graduate of Pennsylvania State College, Mr. Moore joined Norton Company in 1914 as an assistant sales engineer. He became successively sales engineer, assistant sales manager, director of market research, sales manager and general sales manager.

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ERECTION
OPERATION

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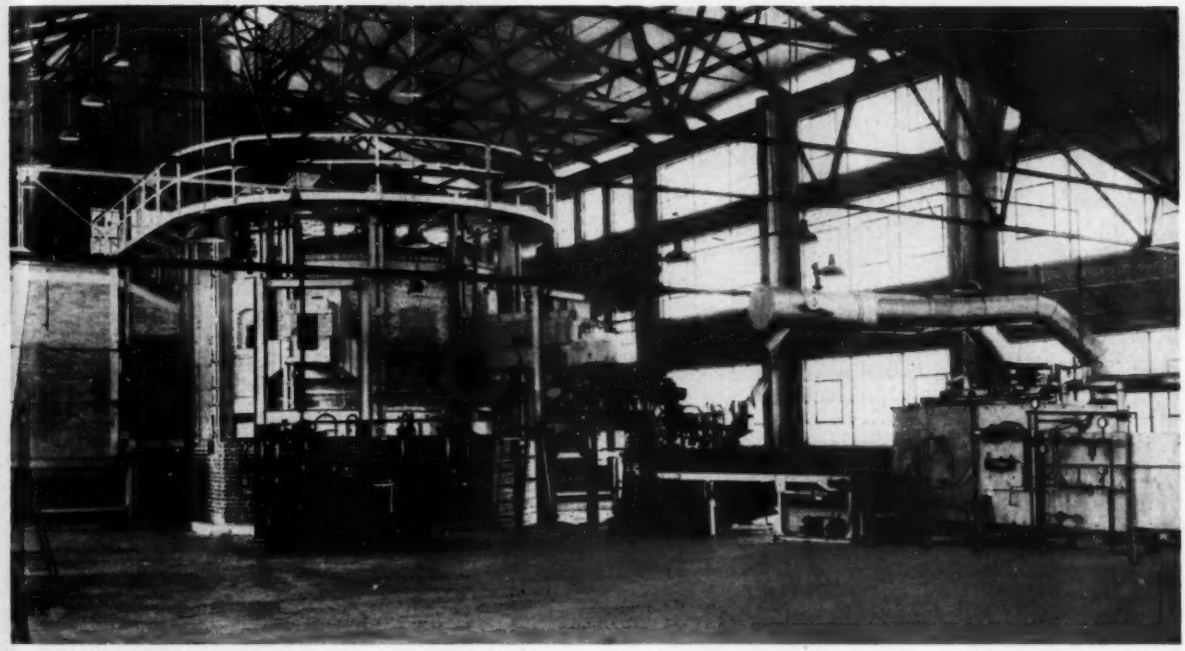

AMCO Installation During Construction Period . . .

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Long-lived, firm closure at tube seat . . . close-tolerance machined for uniformly accurate location in feeder.

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High refractoriness and erosion resistance assure enduring firm closure at tube seat . . . and thorough agitation.

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Retain shape longer for continued, more accurate control of glass gob.

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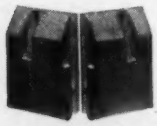
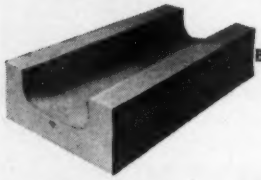


BONUS-BUILDING BURNER BLOCK—Accuracy of dimension for quick, hairline matching to burners.



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W. RONALD LESTER JOINS DOMINION MINERALS

W. Ronald Lester has joined the organization of Dominion Minerals Incorporated. In his new position, Mr. Lester will be responsible for quality control, research and development and technical sales of Aplite Rock.

For the past twenty-one years, Mr. Lester has been associated with the Maryland Glass Corporation as Chief Chemist and Director of Research.

NEW FLUORESCENT COLOR DEVELOPED

The development of a new fluorescent color, called Vis-A-Ray, has been announced by the Duro-Test Corporation.

Walter H. Simson, President, stated that Vis-A-Ray sets a new standard in "see-ability" because it heightens detail perception. The new color concentrates its rays in the spectral range which is easiest on the eyes. In fact, the curve of the new Duro-Test color compiled from readings taken from a sensitive spectro-photometer follows closely the spectral distribution curve of maximum eye sensitivity. This eye-ease quality of Vis-A-Ray is coupled with high efficiency producing pleasing light at a rate of 58 lumens per watt.

MAXSON EDDY JOINS WHEATON GLASS COMPANY

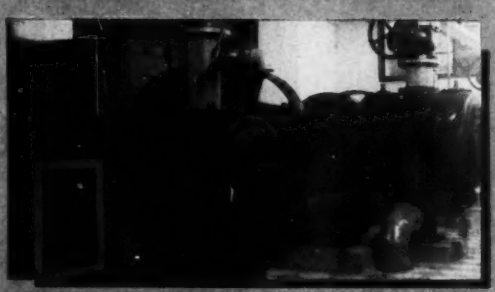
It has been announced by The Wheaton Glass Company that Maxson A. Eddy is now associated with them in an executive capacity. Mr. Eddy will head up the manufacturing and sale of tubing and tubing products.

Mr. Eddy is well known in the glass and packaging circles having formerly been Vice President and General Manager of the Kimble Glass Company. After Owens-Illinois Glass Company absorbed the Kimble Company, he became Vice President of Owens-Illinois and was General Factory Manager of the Kimble Division until his resignation on January 1.

Graduating from the University of Connecticut in 1925 with a degree of Bachelor of Science, Mr. Eddy was associated with the Hartford-Empire Company as a chemist until 1931 when he was appointed Eastern Director of Research and Development for the Owens-Illinois Glass Company.

MATHIESON CHEMICAL TO PURCHASE CHEMICAL COMPANY

Thomas S. Nichols, President of Mathieson Chemical Corporation, has announced that, as a result of negotiations with the directors and principal stockholders of Southern Acid & Sulphur Company, Inc., the company is contracting to purchase the business and assets of that company. Under terms of the agreement, Mathieson will distribute 265,000 shares of its authorized but unissued common stock to the common stockholders of Southern Acid & Sulphur Company, Inc.



NEWLY COMPLETED BOTTLE PLANT

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Our services are specialized in the construction of modern and complete glass plants embodying the most advanced engineering design, automatic methods, and machinery, for the manufacture of bottles, jars, and similar containers, window glass and tableware items, to suit local conditions in foreign countries.

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EFFECT OF CONVECTION CURRENTS ON DISTRIBUTION OF STRIAE IN POTS OF OPTICAL GLASS . . .

(*Continued from page* 148)

cooling was excessive. The colored streaks follow paths taken by the striae and are located in the portions of the melt that would normally be discarded on account of striae.

VI. Conclusion.

The striae distribution in pots of borosilicate 517/645 optical glass was determined, and the role of convection currents in causing this distribution established.

Of the various modifications of the cooling procedure employed, that of lowering the exit temperature formerly used (namely 1075°C) about 50°C was found to be the most effective in reducing convection currents. Stirring could not be continued much below 1025°C or striae from the pot walls would be dragged into the melt.

The use of copper oxide balls, introduced into the melt after removal from the furnace, proved to be satisfactory for tracing convection currents, and thereby judging the efficacy of the cooling technique employed.

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G-E DEVELOPS POWER SUPPLY APPARATUS

A new wide range power supply apparatus which features a continously variable voltage output from 500 to 50,000 volts with a maximum current output of 1 milliampere has been announced by General Electric Company's Special Products Division.

Designed for laboratory applications where a variable voltage at low current is required, the new wide range power supply can be used in electron diffraction studies, mass spectroscopy studies, research on high-intensity screens for cathode ray studies, electron microscopy and projection television experiments.

The high voltage is attained through the use of a radio frequency oscillator, power amplifier, RF transformer and a ladder-type voltage circuit. Use of the RF source, about 40 kc, makes possible reduction of the output ripple at a low value by simple filtering means. This minimizes the equipment's weight and size.

● The first comprehensive exhibit of major china and glass lines since the War will he beld on July 10 when the National China, Glass and Pottery Show will open at the Hotel New Yorker.

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NEW EQUIPMENT AND SUPPLIES

GAS-AIR MIXER

Vapofier Corporation, 10316 South Throop Street, Chicago 43, Illinois, has introduced its Consta-Mixer designed for low initial cost and low upkeep. In accuracy and turn-down range, the company states that the Consta-Mixer fulfills 98 per cent of all gas-air mixing requirements for industrial heating processes. It maintains a constant manifold pressure to any number of burners regardless of variations in burner requirements within the capacity range of the machine. Accordingly, it provides zone control over a number of burners, each having varying demands.

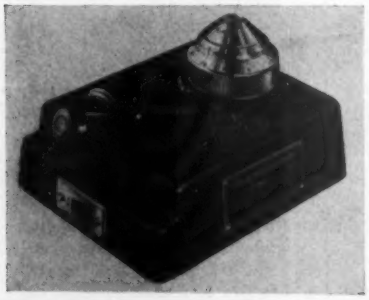
The new mixer maintains a constant mixture ratio at all loads. It handles all types of gas from LP (Butane or Propane) to manufactured, and can be arranged for high-low operation. It maintains a maximum measure of constancy in correct proportions of air and gas.

The Consta-Mixer is available in three sizes, #2, #6 and #10, with capacities ranging from a minimum of 35,000 BTU to 2,000,000 BTU.

OPTI-MIKE, NEW MEASURING INSTRUMENT

Instrument Development Laboratories, Williston Park, Long Island, New York, has announced the development of a new optical instrument which will precisely measure the thickness of glass, quartz, plastics or any other transparent material under conditions where physical access to only one side is possible.

Named "Opti-Mike", the new instrument provides for a need where thickness measurements of transparent materials are required under conditions where due to size and/or shape, it has been difficult to get access to both sides of the material for conventional caliper type measurements. In closed or semi-closed vessels, such as bottles, thin and thick wall tubing, chemical glassware, fluorescent or television tubes, incandescent lamps and other blown or pressed glassware, it has been necessary to break the object to explore its wall thickness.



Opti-Mike will measure wall thickness to an accuracy of one-thousandth of an inch. The production model will measure thickness up to four-tenths of an inch and can be adapted to increased thickness measurements on special order. It has equal facility to measure flat, concave or convex curved materials having smooth ground or patterned surfaces.

The new optical instrument utilizes an optical depth of focus principle wherein the accessible or "near" surface is in contact with the measuring head of the instrument and the second or "far" surface is located by adjustment of the graduated dial until a lamp image is brought in sharp focus on it by optical means.

The instrument is compact, weighing only forty ounces, including a self-contained battery power supply. It is equipped with precision optics, including Bausch & Lomb microscope objective and eye piece.

NEW TURBO-PRESSURE BLOWER

The Chicago Blower Corporation, 4558 W. Congress Street, Chicago 23, Illinois, has announced its new "Chicago" Turbo-Pressure Blower featuring a flanged discharge complete with a companion flange which permits direct attachment to combustion equipment, eliminating need for couplings or union.

The front plate of the new blower is reinforced with triangular gusset plates, eliminating transmissional vibration and "breathing". This reduces the noise level and makes for quiet operation of both single and multistage blowers.

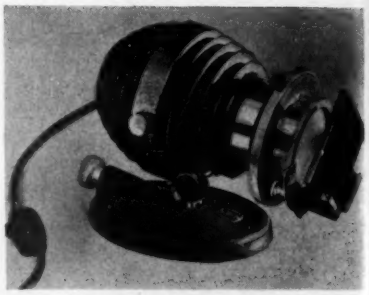
Designed for furnishing air at high pressures for use with oil and gas burners on industrial furnaces, the blower is used extensively for scale blowing, air curtains, pneumatic systems and other applications requiring study, non-pulsating air pressure or suction. Construction throughout is heavy 3/16 welded plate. It is furnished in various sizes to deliver varying volumes of air, ranging from 80 CFM to 6,000 CFM, at pressures from 4 oz. to 2 lbs.

MICROSCOPE ILLUMINATOR

American Optical Company, Scientific Instrument Division, Buffalo, New York, has announced a new Microscope Illuminator designed exclusively for routine and advanced laboratory work.

In the new Spencer No. 735 Lamp, an instrument has been designed with efficient optics and precise, conveniently located mechanical controls. The lamp furnishes both Kohler and parallel illumination for bright field and phase microscopy, photomicrography, microprojection and dark field illumination.

All adjustments are external and located for user convenience. Ventilating fins on the die-cast aluminum body, coupled with natural draft ventilation, assure cool operation. Rack and pinion focusing adjustment is equipped with two buttons for focusing by either left or right hand. A screw-type tilting adjustment, operating in threaded nut, is placed low and to the rear of the base for handling coolness. The silvered, concave glass reflecting mirror is quickly and precisely adjusted at any time by means of three screws. For easy access to lamp, chimney, bulb, reflecting mirror and lens surfaces, the lamp body may be separated by releasing two thumb screws. A standard G.E. 100-watt, 115 volt bayonet base bulb is used.



The new Spencer No. 735 Microscope Illuminator may be obtained with or without an iris diaphragm which has both knurled ring and knob adjustments. A single filter holder for either ground or blue glasses is available; also, a multiple filter holder attachment which accommodates up to four rectangular filters simultaneously.

CATALOGUES RECEIVED

Union Pacific Railroad, Omaha Nebraska, has announced the preparation of Supplement I to "Memorandum of Increased Rates and Charges", which will reflect changes and additions occasioned by the issuance of the new Composite Master Tariff X-162-B and X-166-C, which became effective February 15.

The supplement will show increases authorized in Tariff of Emergency Charges X-168, effective January 11, 1949. It will also contain increase table reflecting 4, 5 and 6 per cent increase to total freight charge of 1¢ to $1,000, including a 3 per cent table for figuring the Federal Transportation Tax.

Johns-Manville, 22 East 40th Street, New York 16, New York, is distributing a folder entitled, "2 New Johns-Manville Refractories for Service to 3000F", which presents pertinent information on 3X Blazecrete (for gunning and patching) and 3X Firecrete (for casting special shapes).

The folder covers recommended uses and technical data, such as cold compressive strength, modulus of rupture, per cent linear change, yield per lb..

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RECOMMEND NO CHANGE IN MINIMUM WAGE . . .

(*Continued from page* 155)

flects bonuses paid for increased production by not over 35 per cent of an industry is unfair to management that does not pay bonuses for increased production. By so declaring that as a minimum wage, these manufacturers are forced to pay added wages above union standards when securing a government contract. Production incentive bonuses paid in addition to standard rates are inaugurated by the management in the hope of cutting down production costs by distributing overhead expense to a larger number of units produced. These incentives reflect extra effort made by employees and have no bearing whatsoever on the minimum wages paid. To inflate an overall standard minimum wage in this manner savors of sharp practice for though it may be substantiated by the language of the act, the spirit which prompted the act in our opinion is lost sight of.

"Evidently the Wage and Hour and Public Contracts Division of the Labor Department has given thought to this philosophy and in many instances where industry is highly unionized has declared the prevailing minimum rate in the union contract to be adequate evidence that it is the prevailing minimum within the industry.

"Finally if an inflated minimum is declared by the Wage and Hour and Public Contracts Division, various government purchasing departments are placed in the position of having to pay more for their requirements than would be paid by private industry under the same conditions. This would be obviated if the minimum wage declared for this or any industry were the same as the minimum wage that is established or will be established under the Fair Labor Standards Act and applicable to all products entering into interstate commerce.

"This Association, therefore, recommends that no change in the prevailing minimum wage in the Pressed and Blown Glassware Industry be made at this time for the reason that over 50 years of contractual relations with the American Flint Glass Workers Union has already produced a negotiated minimum of 83½¢ which is substantially above the apparent minimum 75¢ now being discussed in Congress. By delaying a declaration of a Walsh-Healey minimum, no dual standards would be created and a source of confusing labor negotiations in this industry would be avoided."

KIMBLE NAMES PHILADELPHIA BRANCH MANAGER

E. D. Bowes, of the New York sales staff of Kimble Glass Division of Owens-Illinois Glass Company, has been named Manager of the Kimble branch office in Philadelphia, according to a recent announcement.

Mr. Bowes, who has been with Kimble since 1939, will succeed K. G. Hewitt, who has recently been transferred to Toledo as Sales Manager of Kimble's Container and Accessory Division.

• The second biennial Pacific Chemical Exposition is scheduled to be held in the San Francisco Civic Auditorium on November 1 through 5, 1949.

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NORTH AMERICAN OILTOGAS *Converter**

MAKES IT POSSIBLE to burn No. 1, 2, or 3 Fuel Oil as a Gas in your present Gas Burners

Fig. 1 – Air Heater.

AVOID CRITICAL GAS SHORTAGES

Many industrial ovens, furnaces and boilers are fired with gas burners which do not lend themselves to the substitution of direct oil burners during the trying days of gas curtailments. For such applications North American offers the Oiltogas Converter.

Fig. 2 – Insert Assembly and Mixer.

PRODUCES CLEAN CARBON-FREE GAS FIRES

The principle of the Oiltogas Converter is to supply air at 700° F. to standard North American Aspirator (Gas-Air) Mixers. Into the mixer (through the displacement rod) is injected atomized oil. The hot air immediately vaporizes all of the finely atomized oil and carries the gaseous fuel thus generated to any number of burners.

The air heater shown in Figure 1 is direct oil-fired and is entirely automatic in operation and includes flame safety devices. The amount of fire at the furnace or oven burners is controlled by valves in the hot air line leading to the mixers.

Because of the high air temperatures used and the excellent atomization of the fuel, it is found that even on #3 catalytic fuel oil no carbon or condensate is formed in the piping or burner manifolds. This eliminates the necessity for installing condensate return piping and for periodic cleaning.

*A combination of Standard Combustion Equipment, backed by 30 years of Dependable Service

THE NORTH AMERICAN MANUFACTURING COMPANY
CLEVELAND 1, OHIO

(*Continued from page* 154)

a material speed-up of the reversal operation can be secured as a result.

Heat Recovery and Stack Losses

Heat recovery from the checker system is measurable and capable of control through the frequency of reversal based on top checker temperature measurements.

Furnace pressure regulation keeps air infiltration to a minimum and prevents excessive clogging of the checkers, caused by excessive draft.

The temperatures of exit gases from the checkers can also be measured, even though these conventional measurements are relatively unimportant by comparison to temperature conditions at the top courses. Exit flue temperatures, at least periodically measured, are of assistance in balancing the load between checkers on the same side of the furnace where multiple checkers are employed.

The heat losses in the stack gases are most conveniently measured from a single location in either the stack or the exit flues beyond the reversal valves. Figure 18 shows a temperature record, combining furnace temperatures with stack measurements, the latter illustrating the balance and losses from each side of the furnace as well as detecting any improper seating of the reversal dampers. If a small amount of air is admitted ahead of such a temperature measuring point, since any unburned gases will be fired at that point with resultant increase in temperature indication, this method serves as an effective but crude indicator of incomplete combustion.

Refractory Life

Refractory life, and therefore costs, is influenced by a number of factors which can be controlled through adequate instrumentation.

The maximum temperatures to which refractories are subjected both within the furnace structure and particularly the top of the checker chambers, can be held within safe limits by continuous recording of temperatures in these locations. Rapid temperature fluctuations with resultant spalling are minimized by frequent furnace reversals and controlled rates of fuel flow.

High pressure conditions at elevated temperatures have a well known effect on refractory life. Automatic pressure control through maintenance of required pressure conditions also eliminates flame impingement with its associated effect upon refractory life.

The furnace atmospheres which promote fluxing of the refractories may be eliminated through properly controlled fuel-air relationships. Batch carry-over and resulting deterioration of checker chambers can be solved by both glass level measurement and furnace draft regulation.

Economic Aspects of Tank Instrumentation

A consideration of the economics involved in purchasing and maintaining a tank instrumentation system may be of material assistance in evaluating their application to individual problems.

The present cost of all of the equipment as illustrated in Figure 1 plus a continuous measurement of bridgewall temperature, amounts by approximately $6,500. The current installation and erection costs, with accessory items, are approaching 50 per cent of the equipment costs, or a total of somewhat less than $10,000. When considered as capital investment and amortized over a 10-year period, balancing out interest charges, tax reductions and associated "gobbled-gook", there is a net cost of approximately $1,000 a year.

The yearly cost of replacement parts, charts and supplies, with labor and associated carrying charges for part time of one instrument mechanic (for the number of instruments involved), is calculated to be approximately $1,100. This amount, added to the yearly equipment cost, totals $2,100 a year.

As a typical example, let us assume that such equipment is applied and maintained on a 100-ton tank, packing 85 per cent as saleable ware in the form of containers, at an average net selling price, less cartons, of $65 per ton. Assume also an average fuel consumption of 55 gallons of oil a ton at 10 cents a gallon delivered to the furnace, and an average furnace life of 18 months with a $75,000 rebuilding cost.

Although much of the economic return on an instrument and control investment is secured through the intangibles of smoother plant operation, lower supervisory and management costs, less skilled operators, and a flexibility to meet changes in both raw materials and product requirements, any one of the three following tangible results can establish the "break-even" point. 1) An improvement in glass quality, or the quantity capable of being produced in the forming operation which results in a ⅛ of 1 per cent increase in saleable ware. (Full credit has been given for the value of cullet returned to the melting process.) 2) A reduction in fuel consumption by 1.0 per cent or 6/10 gallons per ton, exclusive of savings in atomizing and air supply costs. 3) An extension of the furnace life by 14 days, exclusive of income losses during rebuilding time and shortening of the heating up period.

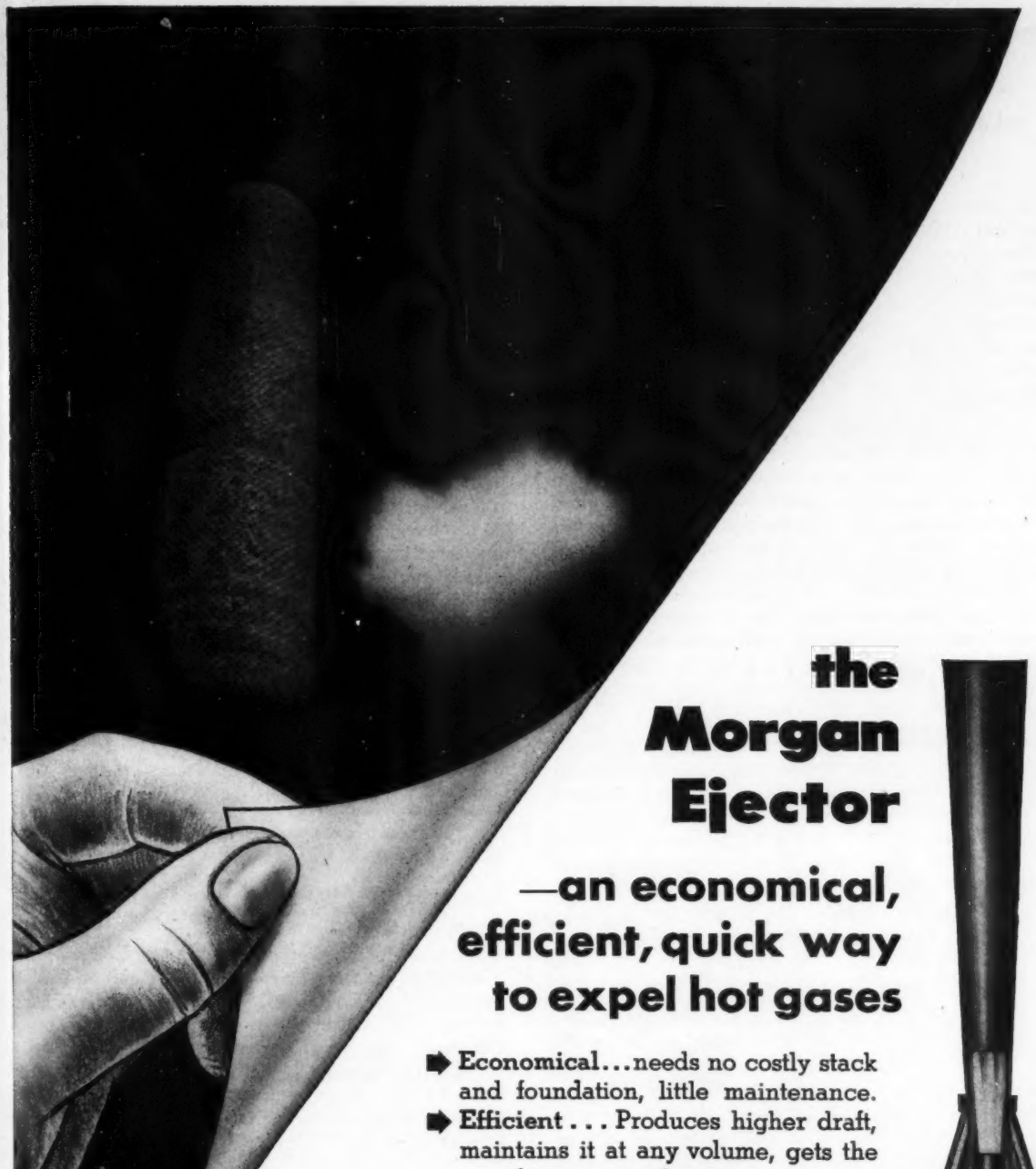
Similar calculations, based upon existing conditions and possible improvements and savings over any desired period of time, may be very useful in evaluating and applying these modern instrumentation tools.

Summary

In summary it is apparent that each specific type and application of instrument has its effect upon a number of the objectives in economic tank operation. It is also apparent that to secure the most extensive results, instruments and controls of different types are inter-related and in several cases directly interconnected.

The overall benefits from a completely coordinated system are greater than the sum of benefits to be derived from all individually operated units. Instrument designs which are adaptable to inter-related usage with all other units are, therefore, desirable.

It is hoped that this presentation of ideas and engineering principles may be used to advantage in the solution of individual and specific glass melting problems in order to obtain the fundamental objectives of highest glass quality at the lowest operating cost.



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- **Economical**...needs no costly stack and foundation, little maintenance.
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FOR SALE

GLASS PLANT, CHICAGO HEIGHTS, ILLINOIS

By order of the United States District Court for the Northern District of Ohio, Western Division, Owens-Illinois Glass Company offers for sale as a unit all real estate, buildings, machinery, production equipment (not including molds), tanks and furnaces (except experimental machinery and furnaces) located at Chicago Heights, Illinois, and which were a part of the assets acquired by Owens-Illinois Glass Company from Kimble Glass Company on July 1, 1946.

In accordance with the order of the Court such property is offered for sale for cash to any purchaser approved by said Court, subject to prior sale, at the fair market value of said property as a glassware manufacturing plant, as determined by an appraisal made by The Lloyd-Thomas Company, which said appraisal has been duly filed with the Clerk of said Court at Toledo, Ohio., where it may be inspected. Additions and improvements made to the property described above since July 1, 1946, and prior to consummation of sale are not included in the appraised value aforesaid but are offered for sale as a part of the unit for an additional consideration equal to the cost thereof to Owens-Illinois Glass Company.

In connection with the sale of the property and additions and improvements thereto above described, Owens-Illinois Glass Company will assign or cause to be assigned to the purchaser thereof for the consideration hereinafter set forth, all its rights in and to the following machinery and equipment leased from Hartford-Empire Company situate on said premises on July 1, 1946, to-wit:

4—4 head I S machines with feeders, revolving tube drives and motors, and variable speed drives and motors

1—5 head I S machine with same

2—36" x 74' lehrs, gas fired with top vertical discharge, motor driven steel plate exhaust fan, and all regular equipment

The consideration to be paid by the purchaser to Owens-Illinois Glass Company for the assignment of its rights in the leased machinery aforesaid shall be cash in such an amount as will reimburse Owens-Illinois Glass Company for a fair proportion of any and all payments made in connection with said leased machinery by Kimble Glass Company or Owens-Illinois Glass Company which may be considered as costs of installation, advance payments for minimum annual royalties, license fees, parts, insurance and taxes.

In the event of such sale, possession will be delivered not later than six months after the consummation of such sale to a purchaser approved by the said Court.

Address all inquiries to

Owens-Illinois Glass Company
Attention: F. G. Morfoot
P. O. Box 1035, Toledo 1, Ohio

JOINING OF GLASS WITH ORGANICS . . .

(*Continued from page* 142)

tion and affect adhesion to the surface.

A comparison of the heat cured modified phenolic adhesives for joining glass surfaces is presented in Table 3. Various heat cures were recommended by the producers and the comparison is made upon five respective heat cures. Cure 1 is inadequate for good bond formation giving low bond strength and poor quality due to the presence of voids containing entrapped solvents.

However, high temperature cures as Cure IV and Cure V are not entirely satisfactory even though more perfect bonds are obtained with high tensile strength. The high temperature cures have a tendency to produce a more brittle film with considerable shrinkage upon cooling and therefore if not slowly cooled to room temperature, glass fracture often occurs. However, if successful cooling is accomplished, certain stress concentrations may develop which induce glass failure well below the modulus of rupture. Consequently intermediate cures should be preferred, either Cure II or Cure III, which give approximately the high tensile value, but undoubtedly have less stress concentrations as was indicated by obtaining adhesive and cohesive failures instead of glass failure.

References

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3. Warren, B. E. *Summary of Work on Atomic Arrangement in Glass.* J. Am. Ceramic Soc. 24:256-261, 1941.
4. Moser, F. *Some Fundamentals of Glass Adhesion.* A.S.T.M. Bulletin, Jan., 1948, No. 150, pp. 51-55.
5. A.S.T.M. Standards Part II, 1947, D897-46T, Tentative Method of Test for Tensile Properties.

ROUND-TABLE DISCUSSION OF LABOR'S DEMANDS

A round-table discussion of labor's economic demands at a session of the annual Personnel Conference in Chicago was headed by E. H. vanDelden, Director of Industrial Relations of Libbey-Owens-Ford Glass Company, as Chairman.

Under the direction of Mr. vanDelden, the Conference made a broad survey of the various patterns now beginning to emerge to form the basis of collective bargaining in coming months.

W. C. HIPPLE, WESTINGHOUSE EXECUTIVE, RETIRES

William C. Hipple, who managed the Trenton, New Jersey, plant of the Westinghouse Lamp Division for almost 30 years, has retired following 47 years with the Division. He was honored by his colleagues at a dinner.

Mr. Hipple was in charge at Trenton from the day the plant opened in 1917 until September 1946 when he transferred to the Bloomfield plant as staff assistant to Ralph C. Stuart, Vice President. In this capacity, he aided in planning a plant expansion program and worked with foreign lamp licensees of the Westinghouse Electrical International Company. He made a survey tour of South American lamp manufacturing facilities a few years ago.

RECENT TRANSLATIONS OF RUSSIAN PAPERS . . .

(*Continued from page* 156)

state than the furnace referred to in Table I. Furnace I was repaired between July 24 and August 4; this explains the sharp rise of productivity in August. Calcium fluoride was added beginning with Sept. 1, and another increase of efficiency resulted. Furnace II was operated without break since March, and its productivity was expected to drop in September and October; it is considered that calcium fluoride addition retarded this drop. The maximum temperature within Furnace I was 1440-1460°C, and within Furnace II (in September and October) 1400-1410°C.

TABLE II

Effect of calcium fluoride on the performance of two Fourcault furnaces

Period		Furnace I		Furnace II	
	CaF_2	A	E	A	E
July	0	551	9.1	620	12.2
August	0	616	12.0	643	13.2
September	1%	700	14.5	667	13.9
October	1%	711	14.5	654	13.1

In Table II, A means again the amount of glass in kg. produced per sq.m. of the furnace per day, and E is the area of glass sheet (in 1000 sq.m.) produced by the furnace per day.

In many instances, addition of 1% of calcium fluoride altered the properties of the glass mass. The rate of solidification of the molten glass was reduced and the solidified samples did not crack. The glass acquired the tendency to form long filaments.

As long as the amount of CaF_2 did not exceed 1.25% no unusual corrosion of the refractories was noticed. Much larger amounts of calcium fluoride give rise to a highly corrosive melt. They cannot be allowed in production.

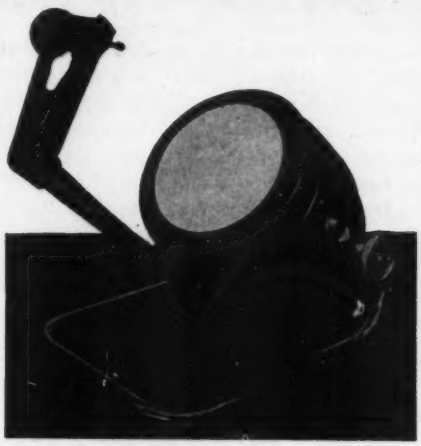
CORNING BEGINS PRODUCTION OF 15 AND 16 INCH TELEVISION BULBS

The first mechanized production of 15 and 16 inch all-glass television bulbs has been started by Corning Glass Works, according to an announcement by William C. Decker, President.

"New types of glass working machinery," he said, "developed after 18 months work by Corning's research laboratories, have made possible automatic manufacture of bulbs of this large size. Resulting economies with the new process will permit price reductions of 24 per cent."

Mr. Decker further stated that because of more exact dimensions and less curvature in the face plate, bulbs made by the new process produce better picture images.

• Foxboro Company has announced the opening of two branch offices. One is located at 123 W. College Avenue, Appleton, Wisconsin, with Milton A. Schreiner as Manager. The other office is at 6225 Brookside Avenue, Kansas City, Missouri, where George J. Willier is Manager.



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INVENTIONS AND INVENTORS . . .

(*Continued from page* 159)

This patent includes the steps of coating glass cullet particles with ash-free carbon in a finely divided state (such as carbon black or colloidal graphite) to provide an adherent carbon protective film on each glass particle, mixing the carbon-coated glass particles with powdered carbon fuel (such as charcoal fines) in sufficient amount to surround the particles and provide a fuel bed, heating the mixture sufficiently to cause combustion of the carbon fuel and fusion of the glass particles into non-adhering spheres formed by surface tension but insufficiently to burn off the carbon protective coatings, and then cooling and cleaning the spheres.

Fig. 5 is a diagrammatic flow sheet corresponding to that in the preceding figure and it is practically self-explanatory. The treated and ground cullet is fed by a screw conveyor 1 to a rotating kiln 2 where the heat treatment takes place and from which it is delivered to a water tank 3. The kiln comprises a ceramic tube about 46 inches long having an electrical heating element on the outside and a stainless steel sleeve on the inside with an inside diameter of 6 inches. Ribs are provided on the inside to produce a rolling action of the contents. The outlet from the kiln provides a drop of about 40 feet to the water tank. The beads harden during the first few feet of this drop.

Several examples of this method are given in the patent, the first being as follows:

This example illustrates the use of carbon black to provide the ash-free carbon protective film, and the use of charcoal to provide the powdered carbon fuel. Also illustrated is the simultaneous production of glass beads of different sizes. Three different sets of charging stock proportions are set forth in columns A, B and C of the following table:

	Parts by weight		
	A	B	C
Glass cullet.....	1,000	1,000	1,000
Carbon black.....	6.8	5.0	7.5
Charcoal fines.....	91	150	175
Water	12	13	16
Other data:			
Pounds per hour of glass fed into kiln.....	50	45	45
R. P. M. of kiln.....	32	32	32
Kiln temperature..°F...	1,675	1,700	1,725-1,750

The glass cullet in formula A comprised 910 parts having a grit size ranging from Nos. 24 to 36, 45 parts having a grit size of No. 50, and 45 parts having a grit size of No. 60. The formula B cullet consisted of 500 parts having a grit size ranging from Nos. 24 to 36, and 500 parts of grit size No. 40. The formula C cullet consisted of 300 parts having a grit size ranging from Nos. 24 to 36, and 700 parts having a grit size ranging from Nos. 40 to 60. In terms of bead sizes produced, the grit 24–36 cullet yielded beads of 16 to 46 mils diameter; the grit 40 cullet yielded beads of about 20 mils diameter; the grit 50 cullet yielded beads of about 15 mils diameter; the grit 60 cullet yielded beads of about 9 mils diameter; and the grit 40–60 cullet yielded beads of

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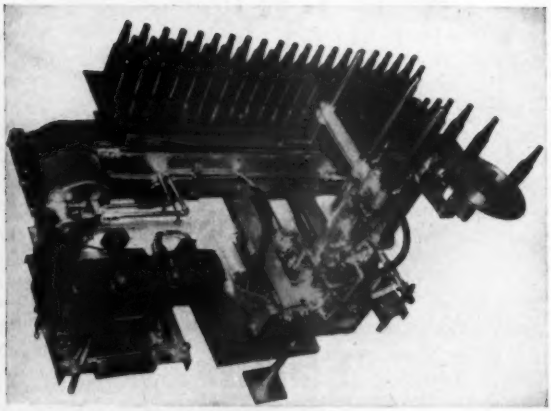

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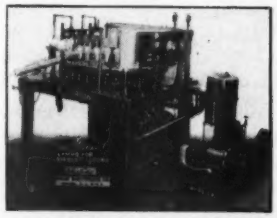
Zanesville, Ohio

AUTOMATIC **EISLER** *AUTOMATIC*
GLASS MACHINERY AND GLASS FORMING UNITS

FOR THE COMPLETE MANUFACTURE OF COLD OR HOT CATHODE LAMPS, INCANDESCENT AND FLUORESCENT LAMPS, RADIO — ELECTRONIC — NEON SIGN — TELEVISION TUBES, VACUUM FLASKS, EYE DROPPERS, etc.

SEALING MACHINES — STEM MAKING MACHINES
MACHINES FOR MANUFACTURING EVERY TYPE ELECTRIC LAMPS

BULB BLOWING MACHINES — AMPULE MACHINES



36 HEAD AUTOMATIC EXHAUST MACHINE

Burners for All Types of Glasswork. Crossfires, Tipping Torches, Pyrex Glass Fires, Oxygen and Hydrogen Fires.

DIFFERENT TYPES AND SHAPES MADE ON EISLER'S AUTOMATIC AMPULE MAKING MACHINES
PLEASE SEND SAMPLE OR DRAWING FOR QUOTATION

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9 to 26 mils diameter. The glass cullet was crushed window glass scrap which was graded to size.

The washing operation was the same as in the preceding patent. It would appear that these two patents make a decided improvement in the art of making glass beads.

The following references are of record in the file of this patent: United States Patent: 2,123,536, Long, July 12, 1938 and 2,332, 361, Anastor et al., Oct. 19, 1943.

L-O-F STOCK REPORT

Directors of Libbey-Owens-Ford Glass Company have declared a quarterly dividend of 75 cents a share payable March 10 to shareholders of record February 25. For the first quarter last year, a 50-cent dividend was paid.

The auditors' report on 1948 operations showed net earnings of $14,207,338 after the usual provision for depreciation, maintenance and taxes, and special provision in the amount of $3,000,000 for property replacement and/or excessive cost of new facilities.

John D. Biggers, President, reported the net sales of the company set a new all-time record when they totalled $113,570,904, which was a gain of 14 per cent over the preceding year. January sales, he added, were substantially greater than in the same month last year and above the December total although current unfilled orders indicate a conservative buying attitude on the part of distributors and some industrial customers.

CLASSIFIED ADVERTISEMENTS

FOR SALE

Approx. 62 tons, .009 Straw Packing Paper, 4" width, large diameter rolls. Make me an offer. Reply Box 87, c/o The Glass Industry, 55 West 42nd Street, New York 18, N. Y.

CLEVELAND CRANE & ENGINEERING PURCHASED BY ENGINEERING FIRM

The Cleveland Crane & Engineering Company has been purchased outright by The McNeil Machine & Engineering Company. Plans have already been made to continue operating Cleveland Crane as heretofore, with no changes in over-all management, organization or policies.

For all practical purposes, the company name will remain the same. The only change contemplated is merging the two companies with the thought that later on stock of the combined companies will be offered to employees and the public.

AMERICAN POTASH STOCK REPORT

The Board of Directors of American Potash and Chemical Corporation declared the quarterly dividend of $1 per share on the $4 Cumulative Preferred Stock, Series A, of the corporation. The dividend is payable March 15, 1949, to holders of record on March 1, 1949.

The Board also declared a dividend of 37½ cents a share on the Class A and Class B stock of the corporation.

INDUSTRIAL
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TELEVISION tube manufacturer in Chicago area requires a GLASS PROCESS ENGINEER for expanding organization. Should be experienced in production process development and control and must have good background in mechanized glass handling problems. Aggressiveness and ability to work with people is essential and manufacturing or design experience in electron tube industry is desirable. Mail resumé outlining age, marital status, education, experience and salary requirements to:

Personnel Director

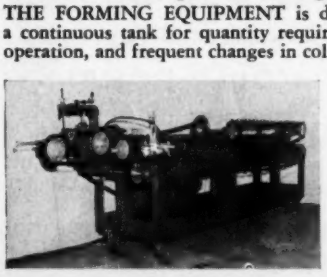
THE RAULAND CORPORATION

4245 N. Knox Avenue, Chicago 41, Illinois

"THE NEW DANNER MACHINE for GLASS TUBING & ROD"

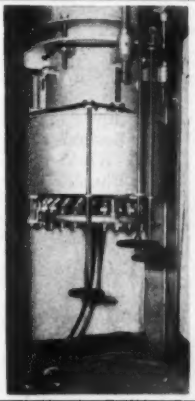
Economical to own and maintain, simple in construction and operation. Unusual flexibility in both forming and drawing equipment, permitting quick changes to meet production needs. Marked advancement as compared to the original Danner machine.

THE FORMING EQUIPMENT is designed so that with minor changes it can be applied to either a continuous tank for quantity requirements or to a day tank for small requirements with intermittent operation, and frequent changes in color or formula.



THE DRAWING & SEVERING EQUIPMENT is suitable for a wide range of sizes and cut lengths. These lengths may be varied by 1" & 2" steps from 52" to 200" by making minor changes.

NEW TYPE SHAPING ELEMENT which unites two or more glass streams at the ware forming plane. This construction provides for greatly increased drawing speeds on the various wall thickness and tube diameters. Small tubing can be drawn in excess of 1000 ft. per minute.



DANNER SPECIAL GLASS MACHINERY
Mt. Vernon Road, Newark, Ohio

A.C.S. SECTION MEETINGS

The American Ceramic Society's Pittsburgh Section's last regular meeting was centered around the ceramic research activities of the fellowships at Mellon Institute. Six members of the various fellowships studying widely different ceramic materials gave short discussions of their work and some of the results obtained. Dr. E. W. Tillotson, Assistant Director of Mellon Institute, welcomed the group and gave a brief history of the development of the Institute.

The Southern Ohio Section was recently the guest of Armco Steel Corporation. The gathering, the Section's largest, was taken on tours of the Armco Research Building and the East Works Plant where they watched the sequency of molten steel from the open-hearth furnaces to the final sheet product. In the evening, Otto Stack of The Carborundum Company spoke on "Examination of Refractories under Microscope."

The annual meeting and dinner dance of the Trenton Section of the American Ceramic Society was recently held. New officers of the Section were elected and duly installed. The Charter of the Section, granted in 1946, was entrusted to John Elder who adjourned the business meeting and turned the remainder of the evening over to the festivities.

At the Northern Ohio Section's recent meeting, Dr. M. J. Bahnsen of the Ferro Enamel Corporation was guest speaker. He chose as his demonstration-lecture, "Modern Porcelain Enameling". A business meeting was held at which officers were elected for the coming year.

CORNING EXTENDS REPLACEMENT OFFER

Advances in manufacturing technique with consequent improvement in quality and durability of Corning Glass Works' Pyrex Flameware products have resulted in an extension of that line's replacement offer from one year to two years, according to a company announcement.

The increased duration of the Pyrex Flameware replacement offer was described by Thomas H. Truslow, General Sales Manager of Corning's Consumer Products Division. "Any glass part of a Pyrex Brand Flameware dish which breaks from heat within two years from the date of purchase, when used according to instructions, may be replaced by any dealer in Pyrex Brand Ware *in exchange* for the broken pieces", Mr. Truslow stated.

The principal contributing factor behind the new offer, is was further stated, is the complete mechanization of both the pressing and tempering operation in the manufacture of Pyrex Flameware products. The utilization of an automatic blowing machine for products formerly made by hand has resulted in a more uniform distribution of glass than was possible previously. This, combined with the adoption of a new automatic tempering machine, makes it possible to produce ware that is far superior in its resistance to mechanical and thermal shock than the previously hand-produced line, Mr. Truslow continued. This is underlined by the fact that new and much more rigorous quality control tests have been developed for these products.

THE SHARP-SCHURTZ COMPANY

CHEMISTS AND CONSULTING ENGINEERS

FOR THE GLASS INDUSTRY

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POTASH Feldspars

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